PHYTOTOXICOLOGY ASSESSMENT INVESTIGATION IN THE VICINITY OF CRANE CANADA INC., STRATFORD-1990

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PHYTOTOXICOLOGY ASSESSMENT INVESTIGATION IN THE VICINITY OF CRANE CANADA INC., STRATFORD 1990

Report prepared by:

G.N. Vasiloff
Phytotoxicology Section
Air Resources Branch
Ontario Ministry of the Environment

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Executive Summary

Crane Canada Inc. has produced porcelain enamelled steel bathtubs, lavatories, kitchen sinks and laundry tubs in its Stratford factory since 1962. Until a water bath system was installed in 1990 at the spray booth area, porcelain overspray was expelled through roof vents to the outside environment. Constituents of the porcelain spray contain boron, fluoride, titanium and other elements.

Since the first annual Phytotoxicology survey in 1977, severe foliar injury has been observed on vegetation near the Crane factory. Chemical analysis of the foliage has detected excessive concentrations of boron and other elements in the injured foliage. At several sites near the plant, concentrations of available boron (hot water soluble) in soils have exceeded the threshold at which injury to vegetation occurs.

In 1990, boron and fluoride concentrations in foliage were considerably lower than the previous year at most survey sites. Although concentrations of both elements declined in 1990, boron and fluoride values exceeded ULN guidelines at 6 and 4 sites, respectively.

Moss bags were established in 1990 to monitor current emissions from the Crane factory. Concentrations of boron, fluoride, barium, sodium, titanium, nickel and copper were clearly elevated at sites close to the factory during the monthly exposure period of June 28-July 27. Following this initial period, concentrations of these and other elements, dropped sharply and remained low during each of the three subsequent monthly periods.

The sharp decrease in 1990 of many elements in foliage and moss bags, is likely due to the abatement measures taken by Crane and the removal of spray particulate from the factory roof.

1. Introduction

In 1962, Crane Canada Inc. started operations at its Stratford plant to produce porcelain enamelled steel bathtubs, lavatories, kitchen sinks and laundry tubs. Since then, a line of acrylic bathtubs and showers was added. Because of the constituents contained in the porcelain sprays (boron, fluoride, titanium, etc.) applied to some of the product lines, the Ministry's Southwest Regional office, suspected that overspray emissions may be reaching the surrounding environment. Therefore, in 1976, the Regional Office requested the Phytotoxicology Section to initiate a vegetation and soil surveillance investigation in the vicinity of the plant.

The initial Phytotoxicology vegetation investigation was conducted in 1977. Foliar analysis indicated the presence of an excessive boron concentration (366 ppm) at a site (1) closest to Crane. In 1978, Phytotoxicology survey results indicated that excessive concentrations of boron were present in vegetation at Sites 1 and 6. At Site 1, the boron concentration in the 1978 vegetation had escalated to 667 ppm.

As a result of these initial findings, the annual vegetation surveillance program was expanded to monitor effects over the immediate surrounding area. In addition to the collection of foliage, soil samples were collected at two sites in 1982 to determine concentrations of available boron. At Site 1, the available boron concentration in soil was 6.3 ppm. This was significantly greater than the 1 ppm (hot water soluble) considered to be potentially phytotoxic. At the control location (Site 12), the average concentration was 0.2 ppm.

In 1988, a resident living directly across from the Crane plant lodged a complaint with the Phytotoxicology Section related to the human health effects of consuming produce from their vegetable garden. The high boron values detected in produce and soils, coupled with the findings of Phytotoxicology annual survey reports, prompted Ministry abatement officers to meet with Crane officials to discuss company emissions and abatement strategies. Crane agreed to install a water bath system in their spray booth area to prevent overspray materials from reaching the outside environment. The company also agreed to remove a heavy deposition of particulate on the flat roof of their building. This particulate, also from the spray operation, had accumulated on the roof over time. Under dry and windy conditions, however, the particulate was being blown into the surrounding neighbourhood. During the summer of 1990 the water bath system was installed and all particulate from the plant roof had been removed.

2. 1989 Phytotoxicology Activities

In 1989, Phytotoxicology survey activities in the vicinity of the Crane plant consisted of the collection of vegetation and soils at all established sites and the implementation of moss bags to monitor current boron and other elemental emissions.

Boron concentrations above the Phytotoxicology Upper Limit of Normal (ULN) guideline of 175 ppm in urban foliage were detected in vegetation at 5 sites. Fluoride

concentrations above the ULN guideline of 35 ppm were found at 7 sites. The most elevated boron and fluoride concentrations were found in vegetation at sites closest to Crane. Elevated or excessive values (above ULN guidelines) of copper, nickel, zinc, manganese, aluminum, barium and titanium were also found at sites closest to the factory. Analysis of moss bags showed that current emissions of boron, fluoride, sodium, barium, titanium, copper and zinc were also highest at locations closest to Crane.

Values of available boron above the 1 ppm potentially phytotoxic level were found in 0-5 cm and 25-30 cm soils at 4 sites close to the Crane plant. At Site 1, an average value of 5.1 ppm was found in 0-5 soil - slightly lower than the 6.3 ppm detected in 1982. At Site 14, available boron found in 0-5 cm soil was 6.3 ppm.

With respect to total boron, concentrations above the 15 ppm ULN guideline were found at 10 of the 11 survey sites. Excessive or elevated concentrations of fluoride, barium, titanium, zinc and nickel were found as sites closest to the Crane facility.

3. 1990 Phytotoxicology Survey Activities

Phytotoxicology activities related to the Crane plant consisted of a vegetation surveillance at 14 sites and the operation of a 19-site moss bag air monitoring network. Both the vegetation and moss bag site locations were increased to provide more comprehensive survey coverage.

3.1 Vegetation Surveillance

The locations of the 14 vegetation survey sites (up from 11 in 1989) and their spatial relationship to the Crane plant are shown in Figure 1. At each site, foliage of survey trees facing the Crane facility was examined for evidence of injury symptoms induced by industrial air pollutants. Injury was noted if present and the severity was rated according to the standard Phytotoxicology injury scale. Leaf samples that displayed boron/fluoride-type symptoms were collected, pressed and submitted for retention in the Phytotoxicology herbarium.

At each site, duplicate samples of the examined foliage facing the Crane plant were collected for chemical analysis. New vinyl gloves were worn by the investigator at each location to prevent sample contamination. All samples were returned to the Phytotoxicology laboratory in Toronto for pre-analysis processing according to a standardized method adopted for vegetation designated as not washed. Processed samples were submitted to the Ministry's Inorganic Trace Contaminants Laboratory for the determination of total boron, fluoride and 10 other elements.

3.2 Vegetation - Injury Observations

The 1990 vegetation surveillance visit was conducted on 28 August 1990 in order to be consistent with sampling dates of previous years and to ensure that any foliar injury induced by air pollutants would not be obscured by the onset of normal late season senescence. Visible injury ratings noted during the 1990 survey visit have been listed in Table

1, along with other ratings obtained from 1984 to 1987. No survey investigation was undertaken in 1988.

Typical and severe boron/fluoride injury symptoms were noted on green ash and silver maple foliage at Site 1. Over 35% of all leaf surfaces displayed terminal, marginal and intercostal necrosis. In the case of the green ash, symptomatology included numerous intercostal lesions that may have been induced by boron contained in particulate emissions from the Crane plant. At Site 14 (directly across the road from Crane), severe injury (over 35%) was also noted on Norway maple and green ash. Intercostal necrotic spotting was also observed on the green ash foliage at this location.

Compared to 1989, injury severity ratings increased at two Sites (5 and 8) in 1990. A decrease in severity was noted at Sites 7 and 10. Ratings remained unchanged on vegetation at 7 locations.

4. Chemical Analysis Results - Vegetation

4.1 Boron

Boron concentrations detected in unwashed foliage collected in 1990 at 14 survey sites in the vicinity of Crane Canada Inc. have been listed in Table 2. In order to provide a historical perspective of boron content in survey foliage, analysis results from 1977 to 1989 have been included in the table.

Boron concentrations found to be in excess of the Phytotoxicology Upper Limit of Normal (ULN) guidelines are underlined. The rationale behind the development of the ULN guideline is provided in the attached appendix.

Compared to 1987 and 1989, boron concentrations found in the 1990 survey vegetation were considerably lower. Concentrations that have been historically high in vegetation at sites close to the Crane plant were sharply lower in 1990 than 1987 and 1989. Overall, 1990 boron concentrations were lower at 10 of 11 survey sites where comparisons are possible with earlier findings. In spite of the general decline, 1990 boron concentrations in excess of the 175 ppm ULN guideline were noted at 6 of the 14 sites.

4.2 Fluoride

A considerable decline in fluoride concentrations was also observed in the 1990 vegetation (Table 3). Compared to 1989 analytical results, 1990 values were lower at 10 of 11 original locations. The mean concentration of fluoride in vegetation from common collection sites declined from 78 in 1989 to 22 ppm in 1990. In spite of the sharp decline, fluoride values in excess of the 35 ppm ULN guideline occurred at 3 original locations (Site 4 - 64 ppm; Site 5 - 36 ppm in silver maple and Site 14 - 78 ppm in the Norway maple and 92 ppm in the green ash foliage). The silver maple at Site 5 and the green ash at Site 14 were sampled for the first time in 1990. At the new survey site (17), a fluoride value of 70 ppm

fluoride was detected in the green ash foliage. In summary, excessive fluoride concentrations were found in a total of 5 vegetation species at 4 survey sites.

Contour maps were produced to illustrate the distribution of boron and fluoride foliar concentrations. (Figures 2 and 3). Contours were computer-produced with a Surfer (TM) software program using the Kriging mapping option. The Kriging method produces contours based on the data from all survey sites. This method produces greater contour accuracy between points of known concentration. Both figures clearly demonstrate that boron and fluoride concentrations were greatest at sites closest to the Crane plant and that the deposition pattern is orientated east and west, with the highest deposition skewed to the east of the source. The contour maps also illustrate that concentrations of both elements decrease with increased distance from the plant.

4.3 Other Elements

A group of 11 other elements was examined in the 1990 foliage collected at survey sites in the vicinity of the Crane plant (Table 4). ULN guidelines for elements appear at the base of the table. Concentrations in the table that exceed the guidelines are underlined. In order to provide a brief historical perspective, values of 10 elements detected in the 1989 foliage have been assembled in Table 5.

Of the 11 other elements examined in the 1990 survey foliage, only nickel exceeded a ULN guideline, and that occurred only at one Site (14). At this location (directly across Erie Street from the Crane plant), the ULN guideline of 7 ppm was exceeded by the 13 ppm found in Norway maple foliage and the 11 ppm in the green ash. In the 1989 foliage (Table 5), excessive levels of nickel were found in both vegetation species at Site 1 as well as in the Norway maple at Site 14.

In 1989, excessive values of copper were detected in sample foliage (both trees) at Site 1 and in the green ash control foliage at Site 12. No copper exceedences occurred in the 1990 foliage.

None of the remaining foliar concentrations of other elements exceeded their respective ULN guidelines in 1989 or 1990. Nevertheless, concentrations of elements such as zinc, aluminum, barium, titanium and sodium were elevated at sites closest to the Crane plant. Contour maps were generated from the analytical data to illustrate the strong relationship between higher concentrations of titanium, barium, nickel, sodium, aluminum, zinc, copper and lead in vegetation and proximity to the Crane plant (Figures 4-11). By contrast, no similar relationship was evident with iron or manganese (Figures 12-13). Although sulphur concentrations found in vegetation were relatively low at all sample sites, Figure 14 indicates that Crane may be a minor sulphur source.

5. Air Monitoring Surveillance - Moss Bags

Moss bags have been used for many years by the Phytotoxicology Section to monitor

atmospheric emissions from a variety of industrial sources. Moss bags are generally used to provide inexpensive air monitoring capability, particularly in areas where vegetation is not present. In some cases, moss bags are used in conjunction with vegetation to differentiate between historical contamination effects and current emissions. Some chemical elements contaminate soils, and their presence may persist for many years. Vegetation situated in the contaminated soil may absorb some of the elements through their root systems and translocate them to the foliage. Depending on the elements, accumulations in the foliage may result in foliar injury. Even though ambient air pollution levels are low, injury to vegetation may continue for a number of years due to the absorption and translocation process. Moss bags, however, are not connected to the soil and therefore they are not affected by historical soil contamination, but rather they monitor only current ambient conditions.

Moss bags consist of three grams (+ 0.1 grams) of laboratory-washed and selected Sphagnum moss fibres contained within a polypropylene screen pouch measuring approximately 15.5 cm x 6.5 cm, which provides a surface area for the moss of about 100 cm^2.

Moss bags were introduced to provide an indication of current emissions from the Crane plant, which was not possible with vegetation and soil because of the historical boron soil contamination. The establishment of a comprehensive moss bag air monitoring network in the area surrounding the Crane plant was initiated in 1989 and continued in expanded form in 1990.

The 1989 moss bag network of 13 sites was increased to 19 in 1990 to provide greater coverage of the surveillance area. Moss bags were installed at each of the 19 sites on June 28, 1990 and then exchanged monthly until the final collection on October 29. This provided four distinct monthly exposure periods; June 28 to July 27, July 27 to August 28, August 28 to September 26 and September 26 to October 29. All exposed bags were stored until the conclusion of the program (October 29) so that the bags could be submitted for analysis as one group.

As Figure 1 shows, moss bags were established at all vegetation survey sites and at 5 additional sites. At most locations, bags were fitted to a plastic holder that was then affixed to a telephone pole or tree. Where suitable mounting structures were unavailable (Sites 1, 12, 15, 18 and 21), moss bag holders were fastened to the top of a wooden rod that in turn was fitted into a hollow square metal pole driven into the ground. Regardless of the mounting arrangement, all moss bags were orientated so that the flat face of the bag faced the Crane plant and were approximately 3 metres from the ground.

Moss bags were submitted to the Phytotoxicology laboratory to be processed according to a standard procedure.[6] Completed samples were forwarded to the Ministry's Inorganic Trace Contaminants laboratory for analysis to determine the concentrations of 11 elements: boron, fluoride, sodium, barium, titanium, copper, zinc, nickel, manganese, aluminum and magnesium.

5.1 Chemical Analysis Results - 1990 Moss Bags

Concentrations of the 11 elements detected during each of the 4 monthly exposure periods in 1990, appear in Tables 6-9. At the base of each table, Phytotoxicology Upper Limit of Normal (ULN) guidelines for copper, zinc and nickel are shown. ULN guidelines for the remaining elements have not been established for moss. The rationale behind the development and interpretation of the guidelines is discussed in the attached appendix.

Concentrations of the 11 elements detected in moss bags during the exposure period from June 28 to July 27 are listed in Table 6. Excessive concentrations of nickel were found in mosses at 6 sites (1, 4, 6, 14, 17 and 21). The highest concentrations were found at Sites 1 and 14 with 62 ppm and 110 ppm, respectively. Figure 1 shows that these 6 sites provide coverage on three sides of the plant and all are relatively close. Although no excessive concentrations of copper were detected at any sites during this exposure period, concentrations of this element were clearly higher at Sites 14, 5, 4 and 1 - all relatively close to the Crane plant. Although no guidelines have been established for the remaining elements, concentrations of boron, fluoride, sodium, barium and titanium were all clearly elevated at sites closest to the plant during the exposure period from July 27 to August 28, 1990.

In the second exposure period (July 27-August 28), concentrations of nickel above the ULN guideline were found in moss bags at Sites 1 and 14. At Site 5, the zinc concentration of 800 ppm equalled the ULN guideline. With respect to copper, the 60 ppm ULN guideline was exceeded at only one location (Site 5 - 70 ppm). During this exposure period, concentrations of boron, fluoride, sodium, barium, and titanium were elevated at sites close to the Crane facility (Table 7).

Concentrations of copper and zinc were below ULN guidelines in moss bags at all locations during the third exposure period (August 28-September 26). The nickel concentration of 25 ppm at Site 15, however, was almost double the ULN guideline. During this exposure period, concentrations of boron, fluoride, sodium, barium and titanium were elevated at Site 14 - located directly across the road from the Crane plant (Table 8).

Table 9 lists concentrations of the 11 elements found in moss bags during the final exposure period of September 26-October 29. No exceedences of the ULN guidelines occurred, although concentrations of boron, fluoride, sodium, barium, titanium and nickel were clearly elevated at Site 14.

In order to track concentration changes of individual elements during the course of the 4 monthly exposure periods, each of the 11 elements is listed in Tables 10-20. At sites close to the plant, concentrations of boron, barium, sodium, titanium, copper, nickel and manganese dropped sharply from the first to the second period and in many cases, continued to decrease until the final period (Tables 10-16). The mean concentrations of the 4 sites (1, 4, 6 & 14) closest to the plant illustrate the extent of the decline. With the exception zinc, magnesium and aluminum, concentrations of all elements at Sites 1, 4, 6 & 14, declined sharply from the first to the fourth monthly exposure periods. At the same 4 sites, zinc, magnesium and aluminum concentrations did not experience a similar or sustained decline.

Typical of decline are the boron concentrations at Site 14 from the first to the fourth exposure periods. The concentration dropped from 570 ppm in the June 28-July 27 period to 86 ppm in the July 27-August 28 period, then down to 63 ppm in the third period, and finally 40 ppm in the final exposure period. Similar sharp declines were also evident at Sites 1, 4, 6 and 21 - all situated close to the Crane plant. Mean boron concentrations of Sites 1, 4, 6 and 14 show that the element declined from 290 ppm in the first period to a mean of 19 ppm in the final period.

Contour maps were produced to visually demonstrate the sharp decline of boron, fluoride, barium, sodium, titanium, zinc, and nickel in moss bags between the first and the last exposure periods (Figures 15-22). Although the contours show that highest concentrations were centered on or near the Crane plant during the first and last exposure periods, during the last period the size and degree of the areas contaminated were considerably reduced compared to the first period. The contour map patterns for aluminum suggest that the Crane plant appears to be the source of this element during the first exposure period, but the source is less defined or poorly focused in the fourth period (Figure 23). Conversely, contour maps for manganese and magnesium in the fourth period suggest that the Crane plant could be the source of these two elements. In the first period, however, there is no clear indication to identify Crane as the source (Figures 24 & 25).

The universally high 1990 concentrations of most elements at sites close to the Crane plant during the first moss bag exposure period were likely a reflection of plant operations and conditions prior to the installation of the water bath system and roof clean up. Although the water bath system was apparently not installed until September, 1990, the precipitous decline that occurred following the first exposure period may be an indication that spray booth operations had ceased temporarily and/or roof clean up had taken place.

Chemical Analysis Results - 1989 Moss Bags

In order to determine the effectiveness of the water bath system in the reduction of emissions and the removal of the roof particulate, moss bag results from 1989 were examined. During the three monthly exposure periods in 1989 (June 29-July 28, July 28-August 28 and August 28-September 28) the water bath system had not been installed and the complete removal of roof particulates had not occurred.

Concentrations of 10 elements detected at each moss bag site during the 1989 field season are shown in Tables 21-30. At the base of each table, mean concentrations of Sites 1, 4, 6 and 14 have been computed because of their close proximity to Crane. In Tables 21-26, mean concentrations of Sites 1, 4, 6 and 14 show that values of boron, fluoride, barium, titanium, manganese and copper dropped rather sharply from the first to the second exposure period, but then increased noticeably again in the third period. Aluminum followed a similar, but less pronounced pattern (Table 27). Mean concentration of sodium, zinc and magnesium during the 3 month exposure period did not generally conform to the patterns observed for the previous 7 elements (Tables 28-30).

Since no abatement or thorough roof clean-up occurred during the three month moss bag exposure period in 1989, the decline in mean concentrations of 7 elements from the first to the second period may be attributed to the annual plant shutdown for summer vacation. Presumably, when the plant was back in production during the third exposure period, concentrations of the 7 elements escalated again.

Conversely, concentrations of many of the elements examined in the 1990 moss bag data remained low in the post water bath installation, roof clean-up and vacation period. Because of these differences in the 1990 and 1989 moss bag analytical data, it was concluded that abatement action taken by Crane had resulted in the reduction of production-related current emissions.

6. Summary

Concentrations of boron detected in the 1990 survey foliage were considerably lower than in 1989 at 10 of 11 of the original survey sites. In spite of the general decline, boron concentrations in excess of the ULN guideline (175 ppm) were found in the 1990 foliage at 6 of the 14 sites. Foliar injury was still observed in 1990 despite reductions in foliar boron concentrations. This was attributed to the uptake of boron from contaminated soil.

Between 1989 and 1990, fluoride values declined sharply at most of the original 11 site locations. Fluoride concentrations in 1990, however, still exceeded the ULN guideline at 4 survey sites.

At many sites close to the Crane plant, foliar concentrations of barium, titanium, sodium, copper, nickel, manganese and aluminum were noticeably elevated but none exceeded ULN guidelines.

In the first 1990 exposure period (June 28-July 27), concentrations of boron, fluoride, barium, sodium, titanium, nickel and copper in moss bags were clearly elevated at those sites located closest to the Crane plant. Concentrations of these, and some of the other elements examined, dropped sharply in the second exposure period and continued to remain low until the fourth and final period. Examination of the 1989 moss bag data indicated that concentrations of many of the elements were also elevated during the initial exposure period, dropped sharply in the second period but climbed again in the final third period. The drop during the second period in 1989 may be attributed to plant shutdown for summer vacations. The subsequent rise in concentrations during the third period was an indication that the plant had resumed production.

The sharp decrease in concentrations of many elements in the survey foliage and in the moss bags following the initial period, may reflect the effectiveness of the abatement measures taken within the Crane plant and the clean-up of particulate material from the roof. It is recommended that vegetation and moss bag surveillance activities be continued in 1992 in order to fully assess the abatement and clean-up action undertaken by the Crane plant.

Appendix

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point source emissions. "Urban" guidelines are based upon samples collected from centres of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normsl, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.

TABLE: 1 Boron-Type Foliar Injury Severity at 14 Survey Sites in the Vicinity of Crane Canada Inc., Stratford 1984-1990

Sample Site Number	Vegetation Species Examined	Approx. Distance & Direction from Crane Canada	Visual Injury Rating[1] 1984	1985	1986	1987	1989	1990
1	silver maple	125 m SW	4	4	NA	4	4	4
1	green ash[2]	125 m SW	4	3	NA	3	4	4
3	silver maple	700 m W	0	0	0	0	0	0
4	Norway maple	150 m NE	2[3]	3	NA	3	3	3
5	Norway maple	200 m NE	1	0	2	3	1	3
	silver maple		-	-	-	-	-	1
6	silver maple	150 m SE	2	3	NA	2	2	2
7	silver maple	425 m S	0	2	NA	2	2	1
8	silver maple	450 m NE	0	0	0	0	1	1
	Norway maple		0	0	0	0	1	2
10	silver maple	850 m N	0	0	2	1	1	0
	Norway maple		0	0	0	0	0	0
11	Norway maple	300 m SSW	0	1	0	1	1	2
12[4]	silver maple	800 m SSE	0	0	0	0	0	0
	green ash		0	0	NA	0	0	0
14	Norway maple	150 m ESE	-	-	-	-	-	4
	green ash		-	-	-	-	-	4
16[5]	Norway maple	650 m SSW	-	-	-	-	-	0
17[5]	green ash	250 m E	-	-	-	-	-	4
22[5]	silver maple	1000 m N	-	-	-	-	-	0
	Norway maple		-	-	-	-	-	0

[1]Phytotoxicology injury rating scale (based on percent of leaf area affected)
0 = normal, 1 = >0-1%, 2 = 2-10%, 3 = 11-35%, 4 = >35%, 5 = 100%

[2]Green ash sampled from 1986 to 1990. White ash sampled in 1984 and 1985.

[3]Injury symptoms partially obscured by senescence.

[4]Control location. [5]New location in 1990. NA - No injury evaluation due to senescence.

TABLE: 2 Boron Concentrations Detected in Unwashed Foliage Collected in the Vicinity of Crane Canada Inc., Stratford 1977-1990

Survey Site Number	Vegetation Sampled	Boron Concentration (ppm - dry weight)[3]											
		1977	1978	1980	1981	1982	1983	1984	1985	1986	1987	1989	1990
1	silver maple	366	667	395	563	700	674	583	457	280	990	880	430
1	green ash[1]	NS	NS	NS	NS	375	267	350	357	200	570	420	310
3	silver maple	NS	54	66	39	65	77	52	59	55	87	61	46
4	Norway maple	NS	NS	178	200	390	311	250	283	180	457	370	210
5	Silver maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	105
5	Norway maple	NS	NS	141	184	195	249	190	130	140	194	138	115
6	silver maple	NS	NS	290	NS	390	467	560	433	130	789	515	385
7	silver maple	NS	123	135	158	155	170	107	107	100	127	155	72
8	silver maple	113	NS	104	100	110	153	113	133	120	145	145	82
8	Norway maple	NS	NS	81	75	135	133	113	94	95	119	90	74
10	silver maple	71	59	NA	118	380	350	347	317	260	450	250	185
10	Norway maple	NS	68	79	66	100	82	102	80	72	80	70	73
11	Norway maple	NS	NS	130	112	165	135	123	100	100	110	115	105
12[2]	silver maple	NS	41	49	66	60	62	63	30	24	NS	27	51
12[2]	green ash	NS	NS	NS	NS	55	68	54	63	50	43	30	55
14	Norway maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	835	475
14	green ash	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	430
16	Norway maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	78
17	green ash	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	230
22	silver maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	36
22	Norway maple	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	71
Phytotoxicology ULN		200	200	200	200	200	200	200	200	175	175	175	175
Mean of Common Sites		NC	169	145	168	243	236	209	175	132	347	241	143

[1]Green ash sampled from 1986 to 1989. [2]Control site. [3]Arithmetic mean of duplicate samples.

NS - Not sampled NA - Data unavailable NC - Not calculated

TABLE: 3 Fluoride Concentrations Detected in Unwashed Foliage Collected in the Vicinity of Crane Canada Inc., Stratford 1989 & 1990

Sample Site Number	Vegetation Species Sampled	Fluoride Concentration (ppm - dry weight)[2] 1989	1990
1	silver maple	200	22
1	green ash	175	27
3	silver maple	36	14
4	Norway maple	64	64
5	silver maple	NS	36
5	Norway maple	41	32
6	silver maple	195	34
7	silver maple	42	5
8	silver maple	30	17
8	Norway maple	17	16
10	silver maple	13	6
10	Norway maple	9	5
11	Norway maple	31	8
12[1]	silver maple	13	3
12	green ash	14	2
14	Norway maple	290	78
14	green ash	NS	92
16	Norway maple	NS	3
17	green ash	NS	70
22	silver maple	NS	4
22	Norway maple	NS	3
Phytotoxicology Upper Limit of Normal (ULN) Guideline for Unwashed Urban Foliage		35	35
Mean of Common Sites		78	22

[1]Control location NS - Vegetation not sampled

[2]Arithmetic mean of duplicate samples

TABLE: 4 Concentrations of 11 Elements Detected in Unwashed Foliage Collected in the Vicinity of Crane Canada Inc., Stratford - 1990.

Sample Site Number	Vegetation Species Sample	Concentration (ppm - dry weight)[3]										
		Cu	Ni	Pb	Zn	Fe	Mn	Al	Ba	S[1]	Ti	Na
1	silver maple	9	6	1	41	90	30	67	26	0.2	45	58
1	green ash	15	6	2	26	67	21	60	49	0.2	34	43
3	silver maple	6	<2	1	27	102	31	73	8	0.1	11	26
4	Norway maple	6	4	4	31	180	17	135	24	0.3	64	60
5	silver maple	5	<2	2	29	170	71	88	12	0.1	36	42
5	Norway maple	7	<2	2	33	215	45	125	18	0.4	35	48
6	silver maple	9	<2	<3	33	125	39	97	16	0.2	44	38
7	silver maple	6	<1	1	27	125	24	77	9	0.1	15	55
8	silver maple	8	<2	1	25	145	63	69	9	0.2	27	29
8	Norway maple	12	<2	2	30	160	21	92	14	0.3	34	44
10	silver maple	6	<1	3	27	235	46	100	6	0.2	22	23
10	Norway maple	5	<1	2	24	155	27	105	12	0.3	25	18
11	Norway maple	7	<1	1	29	105	27	74	9	0.2	15	13
12[2]	silver maple	8	<1	0	34	155	100	47	7	0.2	6	10
12	green ash	14	<1	<1	16	115	34	48	18	0.2	5	12
14	Norway maple	11	13	<2	42	115	32	160	53	0.2	155	120
14	green ash	15	11	<1	27	91	28	115	43	0.2	135	175
16	Norway maple	5	<2	1	21	115	130	62	16	0.2	14	34
17	green ash	7	5	2	24	140	25	115	25	0.2	78	66
22	silver maple	8	<1	2	33	140	21	56	7	0.2	12	13
22	Norway maple	7	<1	1	17	104	21	56	15	0.2	11	8
Phytotoxicology ULN		20	7	60	250	1000	NE	500	NE	0.4	NE	350

[1]Sulphur results given as percent (%) - dry weight. [2]Control location.

[3]Arithmetic mean of duplicate samples. NE- ULN not established for these elements.

TABLE: 5 Concentrations of 10 Elements Detected in Unwashed Foliage Collected in the Vicinity of Crane Canada Inc., Stratford - 1989.

Sample Site Number	Vegetation Species Sample	Concentration (ppm - dry weight)[3] Cu	Ni	Pb	Zn	Fe	Mn	Al	Ba	S[1]	Ti
1	silver maple	21	26	2	74	125	63	210	83	0.2	260
1	green ash	21	23	1	43	82	38	160	84	0.2	195
3	Norway maple	7	1	2	25	120	24	87	8	0.2	25
4	Norway maple	8	5	2	27	175	19	145	25	0.3	34
5	Norway maple	6	4	2	34	185	43	145	16	0.3	36
6	silver maple	10	5	2	40	130	43	130	22	0.2	91
7	silver maple	6	2	3	30	190	48	135	14	0.2	39
8	silver maple	7	2	1	23	145	51	88	20	0.2	27
8	Norway maple	6	1	2	20	130	27	77	12	0.2	22
10	silver maple	7	1	2	22	160	36	72	5	0.2	14
10	Norway maple	7	1	2	30	225	24	125	7	0.2	27
11	Norway maple	9	1	2	31	125	30	102	13	0.3	38
12[2]	silver maple	10	1	1	28	79	23	38	11	0.1	12
12	green ash	22	2	1	31	86	29	48	30	0.1	13
14	Norway maple	14	16	2	49	125	43	230	62	0.2	285
14	green ash	--	--	-	--	--	--	--	--	--	--
16	Norway maple	--	--	-	--	--	--	--	--	--	--
17	green ash	--	--	-	--	--	--	--	--	--	--
22	silver maple	--	--	-	--	--	--	--	--	--	--
22	Norway maple	--	--	-	--	--	--	--	--	--	--
Phytotoxicology ULN		20	7	60	250	1000	NE	500	NE	0.4	NE

[1]Sulphur results given as percent (%) - dry weight. [2]Control location.

[3]Arithmetic mean of duplicate samples. NE- ULN not established for these elements.

TABLE: 6 Concentrations of 11 Elements Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During the Exposure Period June 28 - July 27, 1990

Bag Site Number	Direction & Distance from Crane	Concentration (ppm - dry weight)										
		B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg	Ni
1	125 m SW	270	79	950	230	500	32	82	290	870	1400	62
3	700 m W	7	4	110	50	100	7	59	250	770	1200	6
4	150 m NE	210	130	620	160	350	32	150	260	1100	1700	40
5	200 m NE	12	23	96	51	120	41	590	230	740	1600	8
6	150 m SE	110	120	540	130	200	19	58	240	800	1400	35
7	425 m S	19	19	170	64	100	20	65	250	810	1700	11
8	450 m NE	37	66	260	64	130	9	50	220	780	1700	12
10	850 m N	<5	8	160	39	71	5	47	220	700	1700	3
11	300 m SSW	15	12	200	56	100	8	100	240	750	1600	8
12[1]	800 m SSE	<3	6	100	48	71	5	58	250	750	1700	3
14	150 m ESE	570	380	1600	360	1000	58	130	280	1200	1400	110
15	225 m NW	9	13	120	44	120	6	160	240	1200	1400	5
16	650 m SSW	11	9	180	47	87	10	140	240	820	1600	5
17	250 m E	150	130	530	110	260	16	80	240	860	1400	27
18	450 m WNW	6	7	96	47	68	5	210	280	670	1300	4
19	400 m SW	13	9	130	54	98	9	75	240	730	1300	7
20	600 m S	16	16	130	45	100	16	86	230	740	1300	6
21	300 m ESE	31	43	150	76	1000	12	60	380	11000	4800	15
22	950 m N	-	-	-	-	-	-	-	-	-	-	-
Phytotoxicology ULN		NE	NE	NE	NE	NE	60	800	NE	NE	NE	13

[1]Control location. NE - ULN not established. Site 22 - not established during this period.

TABLE: 7 Concentrations of 11 Elements Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During the Exposure Period July 27 - August 28, 1990

Bag Site Number	Direction & Distance from Crane	Concentration (ppm - dry weight)										
		B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg	Ni
1	125 m SW	50	63	180	80	98	11	40	250	830	920	16
3	700 m W	9	29	69	37	96	7	56	200	930	930	6
4	150 m NE	31	83	110	67	98	19	180	260	850	1400	13
5	200 m NE	9	26	86	36	80	70	800	210	720	1100	5
6	150 m SE	27	43	160	55	130	9	53	280	970	1600	9
7	425 m S	<2	9	38	31	71	8	56	220	8500	1300	3
8	450 m NE	24	53	160	44	90	8	44	210	960	1100	7
10	850 m N	6	22	120	35	120	7	46	230	1000	3100	4
11	300 m SSW	M	M	M	M	M	M	M	M	M	M	M
12[1]	800 m SSE	<1	3	99	35	69	5	43	260	820	910	3
14	150 m ESE	86	90	320	96	160	15	53	230	830	1300	23
15	225 m NW	5	27	55	38	86	6	110	230	840	980	3
16	650 m SSW	<5	7	96	37	86	11	110	250	960	1300	3
17	250 m E	12	28	52	44	76	7	54	230	680	1100	7
18	450 m WNW	<2	14	58	36	84	5	130	230	900	990	3
19	400 m SW	7	19	100	35	72	8	130	220	720	980	4
20	600 m S	8	7	120	32	66	13	150	230	920	910	3
21	300 m ESE	8	23	43	38	73	5	36	240	620	840	4
22	950 m N	<3	8	75	30	60	7	56	230	630	1100	3
Phytotoxicology ULN		NE	NE	NE	NE	NE	60	800	NE	NE	NE	13

[1]Control location. NE - ULN not established. M - Moss bag missing

TABLE: 8 Concentrations of 11 Elements Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During the Exposure Period August 28 - September 26, 1990

Bag Site Number	Direction & Distance from Crane	Concentration (ppm - dry weight)										
		B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg	Ni
1	125 m SW	18	11	180	29	66	5	180	180	780	890	3
3	700 m W	<3	9	110	32	81	5	190	190	810	970	3
4	150 m NE	13	80	120	46	100	12	220	220	880	1800	6
5	200 m NE	8	35	88	35	89	32	210	210	990	1600	4
6	150 m SE	37	160	150	41	100	8	160	160	740	1600	7
7	425 m S	8	31	120	31	94	8	200	200	770	1800	7
8	450 m NE	10	44	160	32	90	7	210	210	740	1500	4
10	850 m N	20	47	150	37	170	7	190	190	1200	3500	5
11	300 m SSW	M	M	M	M	M	M	M	M	M	M	M
12[1]	800 m SSE	<3	12	150	28	84	5	180	180	760	950	<3
14	150 m ESE	63	230	190	53	160	10	97	97	820	1700	13
15	225 m NW	<4	18	98	32	72	5	210	210	750	990	25
16	650 m SSW	7	16	150	32	80	10	200	200	840	1400	3
17	250 m E	15	82	160	34	87	6	180	180	790	1400	5
18	450 m WNW	<4	14	110	29	80	5	190	190	750	910	<3
19	400 m SW	<5	9	150	30	87	5	200	200	900	1100	3
20	600 m S	<3	2	130	28	76	10	180	180	770	970	4
21	300 m ESE	9	ND	88	37	92	5	98	98	990	1000	4
22	950 m N	7	19	150	31	72	7	190	190	830	1500	3
Phytotoxicology ULN		NE	NE	NE	NE	NE	60	800	NE	NE	NE	NE

[1]Control location. NE - ULN not established. M - Moss bag missing

ND - No data.

TABLE: 9 Concentrations of 11 Elements Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During the Exposure Period September 26 - October 29, 1990

Bag Site Number	Direction & Distance from Crane	Concentration (ppm - dry weight)										
		B	F	Na	Ba	Ti	Cu	Zn	Mn	Al	Mg	Ni
1	125 m SW	8	ND	49	36	82	5	64	96	860	1000	3
3	700 m W	<5	13	57	32	110	6	52	1800	940	1000	3
4	150 m NE	20	110	120	42	140	12	130	100	1200	1800	7
5	200 m NE	10	57	87	36	120	26	310	96	1100	1500	6
6	150 m SE	7	77	63	31	97	5	53	150	870	960	4
7	425 m S	7	35	56	33	120	12	69	180	1300	1300	3
8	450 m NE	20	ND	100	39	120	9	68	110	880	1400	5
10	850 m N	7	33	68	35	140	8	86	120	1200	1800	4
11	300 m SSW	6	ND	67	35	100	8	120	120	870	1300	4
12[1]	800 m SSE	<5	15	54	32	93	5	44	170	880	970	3
14	150 m ESE	40	240	200	53	190	10	50	140	930	1200	12
15	225 m NW	6	14	65	33	97	5	89	88	990	1100	<3
16	650 m SSW	<4	18	43	34	92	9	83	210	630	1100	3
17	250 m E	11	100	77	30	100	6	51	170	820	1100	3
18	450 m WNW	<2	10	40	34	74	5	120	170	690	940	4
19	400 m SW	<3	12	69	30	82	6	77	170	850	1100	<3
20	600 m S	<4	14	71	32	120	25	78	160	850	980	3
21	300 m ESE	12	43	59	37	100	6	46	170	1000	1000	4
22	950 m N	<4	ND	65	29	84	7	62	110	840	1100	4
Phytotoxicology ULN		NE	NE	NE	NE	NE	60	800	NE	NE	NE	13

[1]Control location. NE - ULN not established. M - Moss bag missing

ND - No data.

TABLE: 10 Concentrations of Boron[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	270	50	18	8
3	700 m W	7	9	<3	<5
4	150 m NE	210	31	13	20
5	200 m NE	12	9	8	10
6	150 m SE	110	27	37	7
7	425 m S	19	<2	8	7
8	450 m NE	37	24	10	20
10	850 m N	<5	6	20	7
11	300 m SSW	15	<4	ND	6
12[2]	800 m SSE	<3	<1	<3	<5
14	150 m ESE	570	86	63	40
15	225 m NW	9	5	<4	6
16	650 m SSW	11	<5	7	<4
17	250 m E	150	12	15	11
18	450 m WNW	6	<2	<4	<2
19	400 m SW	13	7	<5	<3
20	600 m S	16	8	<3	<4
21	300 m ESE	31	8	9	12
22	950 m N	ND	<3	7	<4
Mean Concentrations - Sites 1, 4, 6 & 14		290	49	33	19

[1]ppm - dry weight. [2]Control Location ND - No data.

TABLE: 11 Concentrations of Barium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	230	80	29	36
3	700 m W	50	37	32	32
4	150 m NE	160	67	46	42
5	200 m NE	51	36	35	36
6	150 m SE	130	55	41	31
7	425 m S	64	31	31	33
8	450 m NE	64	44	32	39
10	850 m N	39	35	37	35
11	300 m SSW	56	32	ND	35
12[2]	800 m SSE	48	35	28	32
14	150 m ESE	360	96	53	53
15	225 m NW	44	38	32	33
16	650 m SSW	47	37	32	34
17	250 m E	110	44	34	30
18	450 m WNW	47	36	29	34
19	400 m SW	54	35	30	30
20	600 m S	45	32	28	32
21	300 m ESE	76	38	37	37
22	950 m N	ND	30	31	29
Mean Concentrations - Sites 1,4,6 & 14		220	75	42	41

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 12 Concentrations of Sodium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	950	180	180	49
3	700 m W	110	69	110	57
4	150 m NE	620	110	120	120
5	200 m NE	96	86	88	87
6	150 m SE	540	160	150	63
7	425 m S	170	38	120	56
8	450 m NE	260	160	160	100
10	850 m N	160	120	150	68
11	300 m SSW	200	40	ND	67
12[2]	800 m SSE	100	99	150	54
14	150 m ESE	1600	320	190	200
15	225 m NW	120	55	98	65
16	650 m SSW	180	96	150	43
17	250 m E	530	52	160	77
18	450 m WNW	96	58	110	40
19	400 m SW	130	100	150	69
20	600 m S	130	120	130	71
21	300 m ESE	150	43	88	59
22	950 m N	ND	75	150	65
Mean Concentrations - Sites 1,4,6 & 14		928	193	160	108

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 13 Concentrations of Titanium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	500	98	66	82
3	700 m W	100	96	81	110
4	150 m NE	350	98	100	140
5	200 m NE	120	80	89	120
6	150 m SE	200	130	100	97
7	425 m S	100	71	94	120
8	450 m NE	130	90	90	120
10	850 m N	71	120	170	140
11	300 m SSW	100	75	ND	100
12[2]	800 m SSE	71	69	84	93
14	150 m ESE	1000	160	160	190
15	225 m NW	120	86	72	97
16	650 m SSW	87	86	80	92
17	250 m E	260	76	87	100
18	450 m WNW	68	84	80	74
19	400 m SW	98	72	87	82
20	600 m S	100	66	76	120
21	300 m ESE	1000	73	92	100
22	950 m N	ND	60	72	84
Mean Concentrations - Sites 1,4,6 & 14		513	122	107	127

[1]ppm - dry weight [2]Control location. ND - No data.

TABLE: 14 Concentrations of Copper[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	32	11	5	5
3	700 m W	7	7	5	6
4	150 m NE	32	19	12	12
5	200 m NE	41	70	32	26
6	150 m SE	19	9	8	5
7	425 m S	20	8	8	12
8	450 m NE	9	8	7	9
10	850 m N	5	7	7	8
11	300 m SSW	8	5	ND	8
12[2]	800 m SSE	5	5	5	5
14	150 m ESE	58	15	10	10
15	225 m NW	6	6	5	5
16	650 m SSW	10	11	10	9
17	250 m E	16	7	6	6
18	450 m WNW	5	5	5	5
19	400 m SW	9	8	5	6
20	600 m S	16	13	10	25
21	300 m ESE	12	5	5	6
22	950 m N	ND	7	7	7
Mean Concentrations - Sites 1,4,6 & 14		35	14	9	8

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 15 Concentrations of Nickel[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	62	16	3	3
3	700 m W	6	6	3	3
4	150 m NE	40	13	6	7
5	200 m NE	8	5	4	6
6	150 m SE	35	9	7	4
7	425 m S	11	3	7	3
8	450 m NE	12	7	4	5
10	850 m N	3	4	5	4
11	300 m SSW	8	3	ND	4
12[2]	800 m SSE	3	3	<3	3
14	150 m ESE	110	23	13	12
15	225 m NW	5	3	25	<3
16	650 m SSW	5	3	3	3
17	250 m E	27	7	5	3
18	450 m WNW	4	3	<3	4
19	400 m SW	7	4	3	<3
20	600 m S	6	3	4	3
21	300 m ESE	15	4	4	4
22	950 m N	ND	3	3	4
Mean Concentrations - Sites 1,4,6 & 14		62	15	7	7

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 16 Concentrations of Manganese[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	290	250	180	96
3	700 m W	250	200	190	180
4	150 m NE	260	260	220	100
5	200 m NE	230	210	210	96
6	150 m SE	240	280	160	150
7	425 m S	250	220	200	180
8	450 m NE	220	210	210	110
10	850 m N	220	230	190	120
11	300 m SSW	240	230	ND	120
12[2]	800 m SSE	250	260	180	170
14	150 m ESE	280	230	97	140
15	225 m NW	240	230	210	88
16	650 m SSW	240	250	200	210
17	250 m E	240	230	180	170
18	450 m WNW	280	230	190	170
19	400 m SW	240	220	200	170
20	600 m S	230	230	180	160
21	300 m ESE	380	240	98	170
22	950 m N	ND	230	190	110
Mean Concentrations - Sites 1,4,6 & 14		268	255	164	122

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 17

Concentrations of Magnesium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	1400	920	890	1000
3	700 m W	1200	930	970	1000
4	150 m NE	1700	1400	1800	1800
5	200 m NE	1600	1100	1600	1500
6	150 m SE	1400	1600	1600	960
7	425 m S	1700	1300	1800	1300
8	450 m NE	1700	1100	1500	1400
10	850 m N	1700	3100	3500	1800
11	300 m SSW	1600	1200	ND	1300
12[2]	800 m SSE	1700	910	950	970
14	150 m ESE	1400	1300	1700	1200
15	225 m NW	1400	980	990	1100
16	650 m SSW	1600	1300	1400	1100
17	250 m E	1400	1100	1400	1100
18	450 m WNW	1300	990	910	940
19	400 m SW	1300	980	1100	1100
20	600 m S	1300	910	970	980
21	300 m ESE	4800	840	1000	1000
22	950 m N	ND	1100	1500	1100
Mean Concentrations - Sites 1,4,6 & 14		1475	1305	1498	1240

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 18 Concentrations of Zinc[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	82	40	37	64
3	700 m W	59	56	41	52
4	150 m NE	150	180	95	130
5	200 m NE	590	800	300	310
6	150 m SE	58	53	46	53
7	425 m S	65	56	58	69
8	450 m NE	50	44	43	68
10	850 m N	47	46	81	86
11	300 m SSW	100	160	ND	120
12[2]	800 m SSE	58	43	38	44
14	150 m ESE	130	53	56	50
15	225 m NW	160	110	78	89
16	650 m SSW	140	110	100	83
17	250 m E	80	54	56	51
18	450 m WNW	210	130	100	120
19	400 m SW	75	130	70	77
20	600 m S	86	150	64	78
21	300 m ESE	60	36	60	46
22	950 m N	ND	56	41	62
Mean Concentrations - Sites 1,4,6 & 14		105	82	59	74

[1]ppm - dry weight. [2]Control location NA - No data.

TABLE: 19 Concentrations of Fluoride[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	79	63	11	ND
3	700 m W	4	29	9	13
4	150 m NE	130	83	80	110
5	200 m NE	23	26	35	57
6	150 m SE	120	43	160	77
7	425 m S	19	9	31	35
8	450 m NE	66	53	44	ND
10	850 m N	8	22	47	33
11	300 m SSW	12	8	ND	ND
12[2]	800 m SSE	6	3	12	15
14	150 m ESE	380	90	230	240
15	225 m NW	13	27	18	14
16	650 m SSW	9	7	16	18
17	250 m E	130	28	82	100
18	450 m WNW	7	14	14	10
19	400 m SW	9	19	9	12
20	600 m S	16	7	2	14
21	300 m ESE	43	23	ND	43
22	950 m N	ND	8	19	ND
Mean Concentrations - Sites 1,4,6 & 14		177	70	120	142

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 20 Concentrations of Aluminum[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 4 Monthly Exposure Periods from June to October, 1990

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods			
		June 28 -July 27	July 27 -Aug. 28	August 28 -Sept. 26	Sept. 26 -Oct. 29
1	125 m SW	870	830	780	860
3	700 m W	770	930	810	940
4	150 m NE	1100	850	880	1200
5	200 m NE	740	720	990	1100
6	150 m SE	800	970	740	870
7	425 m S	810	850	770	1300
8	450 m NE	780	960	740	880
10	850 m N	700	1000	1200	1000
11	300 m SSW	750	810	ND	870
12[2]	800 m SSE	750	820	760	880
14	150 m ESE	1200	830	820	930
15	225 m NW	1200	840	750	990
16	650 m SSW	820	960	840	630
17	250 m E	860	680	790	820
18	450 m WNW	670	900	750	690
19	400 m SW	730	720	900	850
20	600 m S	740	920	770	850
21	300 m ESE	1100	620	990	1000
22	950 m N	ND	630	830	840
Mean Concentrations - Sites 1,4,6 & 14		993	870	805	965

[1]ppm - dry weight. [2]Control location. ND - No data.

TABLE: 21 Concentrations of Boron[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	350	110	170
3	700 m W	23	16	15
4	150 m NE	45	58	60
5	200 m NE	11	13	17
6	150 m SE	160	110	210
7	425 m S	66	30	16
8	450 m NE	14	30	23
10	850 m N	10	12	12
11	300 m SSW	19	18	32
12[2]	800 m SSE	12	7	6
14	150 m ESE	260	290	430
15	225 m NW	14	19	26
16	650 m SSW	13	12	12
Mean Concentrations - Sites 1,4,6 & 14		204	142	218

[1]ppm - dry weight.

[2]Control location.

TABLE: 22 Concentrations of Fluoride[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	250	79	170
3	700 m W	34	26	35
4	150 m NE	67	120	110
5	200 m NE	23	22	37
6	150 m SE	290	250	210
7	425 m S	88	44	32
8	450 m NE	23	40	42
10	850 m N	19	20	20
11	300 m SSW	25	NA	57
12[2]	800 m SSE	17	11	14
14	150 m ESE	250	260	465
15	225 m NW	NA	28	79
16	650 m SSW	24	20	37
Mean Concentrations - Sites 1,4,6 & 14		214	177	239

[1]ppm - dry weight. NA - Data not available.

[2]Control location.

TABLE: 23 Concentrations of Barium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	230	85	99
3	700 m W	43	36	35
4	150 m NE	61	62	100
5	200 m NE	35	30	46
6	150 m SE	180	68	160
7	425 m S	89	43	41
8	450 m NE	34	46	40
10	850 m N	37	44	44
11	300 m SSW	41	33	63
12[2]	800 m SSE	40	35	35
14	150 m ESE	140	96	230
15	225 m NW	37	39	48
16	650 m SSW	38	33	42
Mean Concentrations - Sites 1,4,6 & 14		153	78	147

[1]ppm - dry weight.

[2]Control location.

TABLE: 24 Concentrations of Titanium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	260	92	180
3	700 m W	110	88	89
4	150 m NE	130	140	130
5	200 m NE	110	110	92
6	150 m SE	130	150	170
7	425 m S	120	120	92
8	450 m NE	120	89	95
10	850 m N	96	99	99
11	300 m SSW	90	81	96
12[2]	800 m SSE	75	75	90
14	150 m ESE	360	310	630
15	225 m NW	110	84	110
16	650 m SSW	92	81	84
Mean Concentrations - Sites 1,4,6 & 14		220	173	278

[1]Parts per million (ppm) - dry weight.

[2]Control location.

TABLE: 25 Concentrations of Manganese[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	180	150	140
3	700 m W	100	100	110
4	150 m NE	150	96	150
5	200 m NE	120	90	150
6	150 m SE	170	100	140
7	425 m S	150	120	130
8	450 m NE	110	130	120
10	850 m N	140	120	120
11	300 m SSW	130	100	150
12[2]	800 m SSE	120	110	120
14	150 m ESE	160	120	140
15	225 m NW	110	110	77
16	650 m SSW	130	110	150
Mean Concentrations - Sites 1,4,6 & 14		165	117	143

[1]ppm - dry weight.

[2]Control location.

TABLE: 26 Concentrations of Copper[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	40	14	15
3	700 m W	8	6	8
4	150 m NE	12	17	22
5	200 m NE	27	12	37
6	150 m SE	31	13	27
7	425 m S	17	11	10
8	450 m NE	6	8	8
10	850 m N	8	7	7
11	300 m SSW	7	7	11
12[2]	800 m SSE	7	5	5
14	150 m ESE	22	16	37
15	225 m NW	8	6	8
16	650 m SSW	8	8	10
Mean Concentrations - Sites 1,4,6 & 14		26	15	25

[1]ppm - dry weight.

[2]Control location.

TABLE: 27 Concentrations of Aluminum[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	1300	930	1100
3	700 m W	1100	820	980
4	150 m NE	990	1200	1200
5	200 m NE	1000	990	990
6	150 m SE	1200	1100	1200
7	425 m S	1000	1000	1000
8	450 m NE	970	840	1300
10	850 m N	1100	840	840
11	300 m SSW	780	980	990
12[2]	800 m SSE	920	980	1100
14	150 m ESE	1400	1100	1300
15	225 m NW	1000	930	1200
16	650 m SSW	960	850	1000
Mean Concentrations - Sites 1,4,6 & 14		1223	1083	1200

[1]Parts per million (ppm) - dry weight.

[2]Control location.

TABLE: 28 Concentrations of Sodium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	960	300	480
3	700 m W	110	71	94
4	150 m NE	220	180	180
5	200 m NE	100	85	80
6	150 m SE	570	300	510
7	425 m S	370	120	110
8	450 m NE	170	140	160
10	850 m N	180	95	95
11	300 m SSW	150	100	180
12[2]	800 m SSE	110	68	84
14	150 m ESE	720	690	180
15	225 m NW	92	100	130
16	650 m SSW	160	130	100
Mean Concentrations - Sites 1,4,6 & 14		618	368	338

[1]ppm - dry weight.

[2]Control location.

TABLE: 29 Concentrations of Zinc[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	78	62	62
3	700 m W	68	57	62
4	150 m NE	89	72	130
5	200 m NE	460	85	300
6	150 m SE	67	74	79
7	425 m S	69	82	71
8	450 m NE	55	63	55
10	850 m N	60	65	65
11	300 m SSW	63	140	130
12[2]	800 m SSE	54	67	69
14	150 m ESE	74	75	140
15	225 m NW	51	74	77
16	650 m SSW	68	100	150
Mean Concentrations - Sites 1,4,6 & 14		77	71	103

[1]ppm - dry weight.

[2]Control location.

TABLE: 30 Concentrations of Magnesium[1] Detected in Moss Bags in the Vicinity of Crane Canada Inc., Stratford During Each of the 3 Monthly Exposure Periods from June to September, 1989

Bag Site Number	Direction & Distance from Crane	Moss Bag Exposure Periods: June 29 -July 28	July 28 -Aug. 28	August 28 -Sept. 28
1	125 m SW	1000	910	940
3	700 m W	1000	1000	970
4	150 m NE	1600	1700	1500
5	200 m NE	1300	1200	1400
6	150 m SE	1300	1500	1100
7	425 m S	1600	1600	1300
8	450 m NE	1200	1300	1300
10	850 m N	1800	1400	1400
11	300 m SSW	1200	1100	1000
12[2]	800 m SSE	1100	990	940
14	150 m ESE	1400	1300	1100
15	225 m NW	1500	1100	890
16	650 m SSW	1500	1200	1000
Mean Concentrations - Sites 1,4,6 & 14		1325	1353	1160

[1]ppm - dry weight.

[2]Control location.

FIGURE: 1 Locations of Vegetation and Moss Bag Sample Sites in the Vicinity of Crane Canada Inc., Stratford - 1990

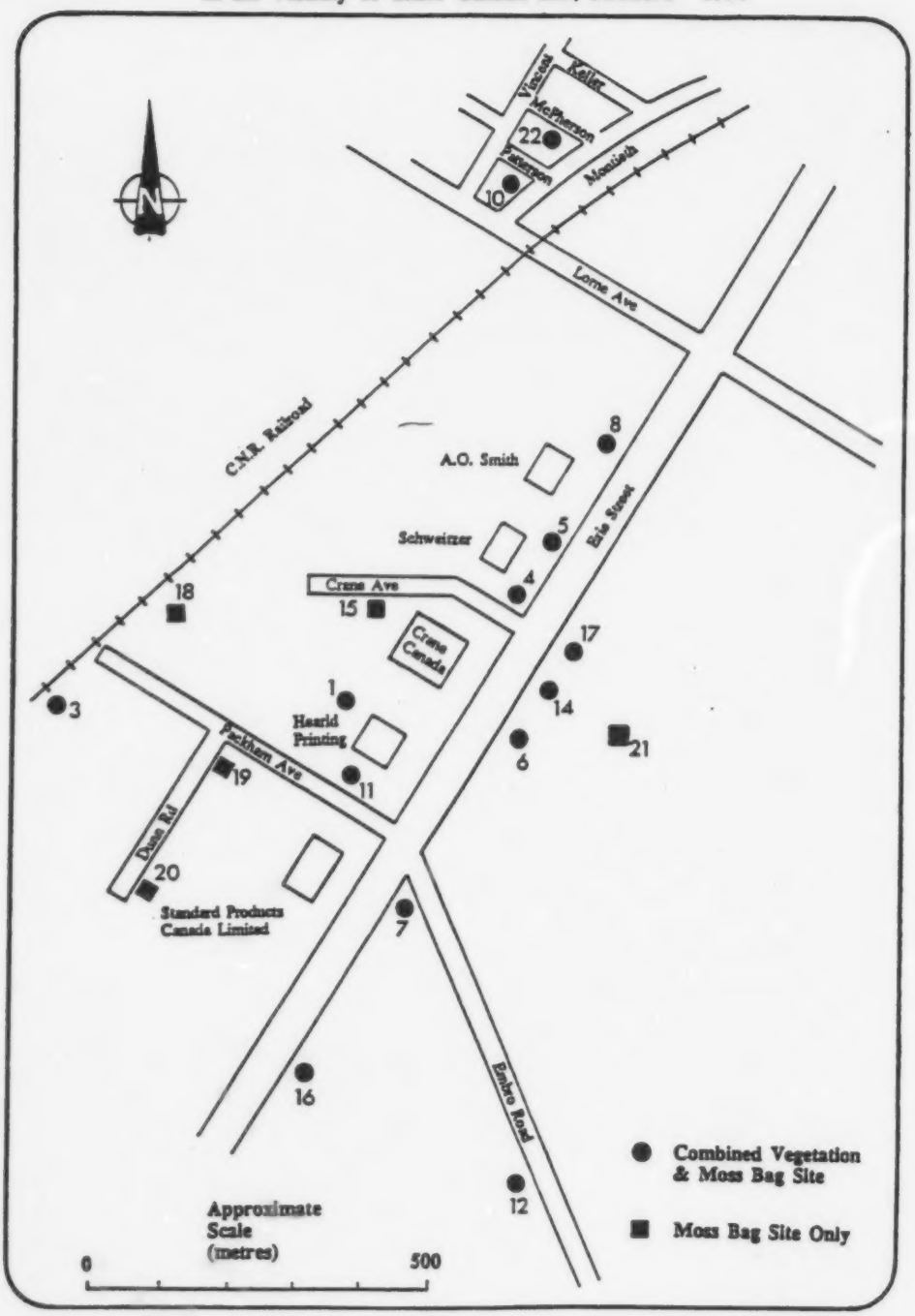
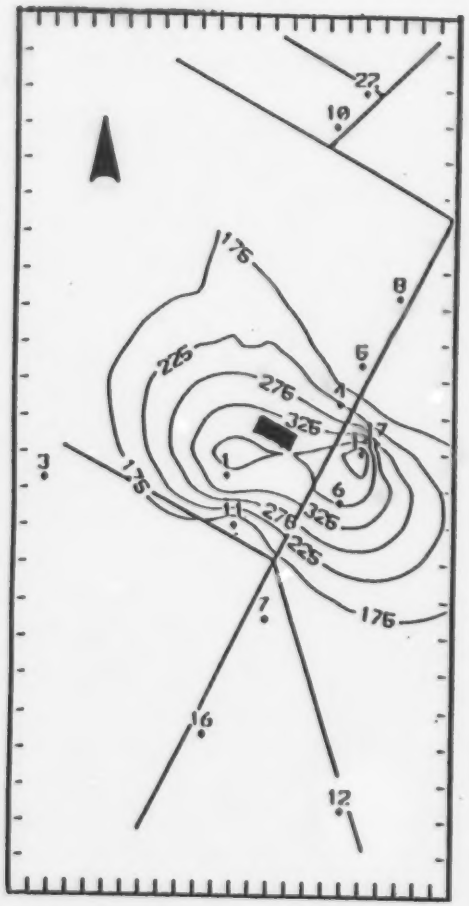


FIGURE: 2

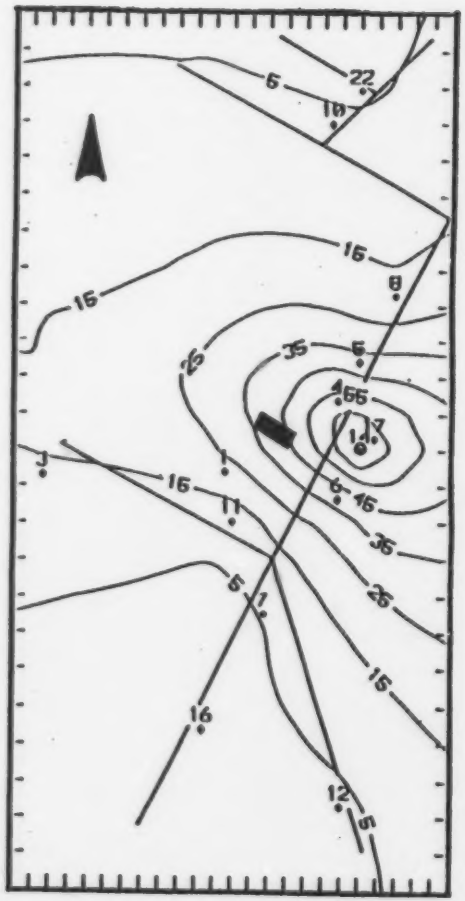
Contour Map of Boron Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour Intervals - 50 ppm

FIGURE: 3

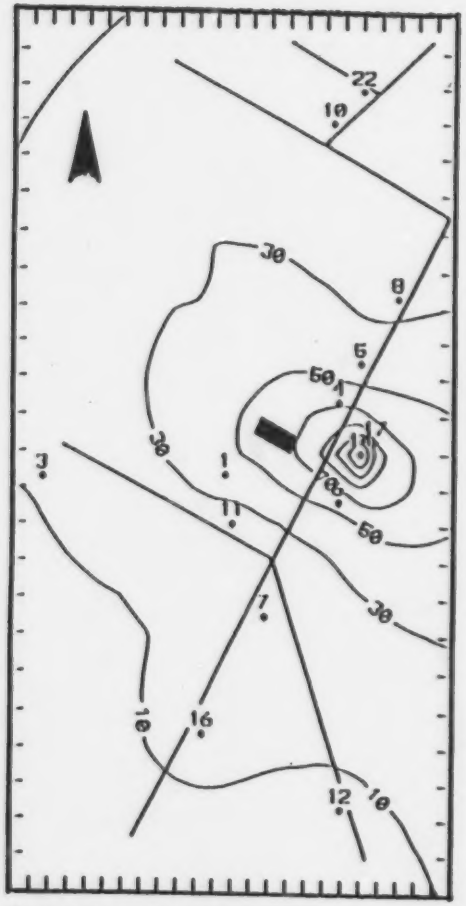
Contour Map of Fluoride Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour Intervals - 10 ppm

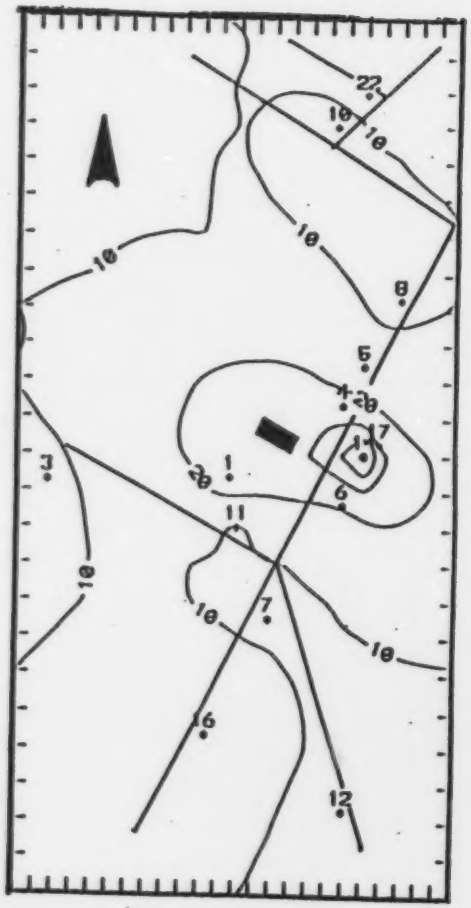
Concentration values - ppm - dry weight

FIGURE: 4 Contour Map of Titanium Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour Intervals - 20 ppm

FIGURE: 5 Contour Map of Barium Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990

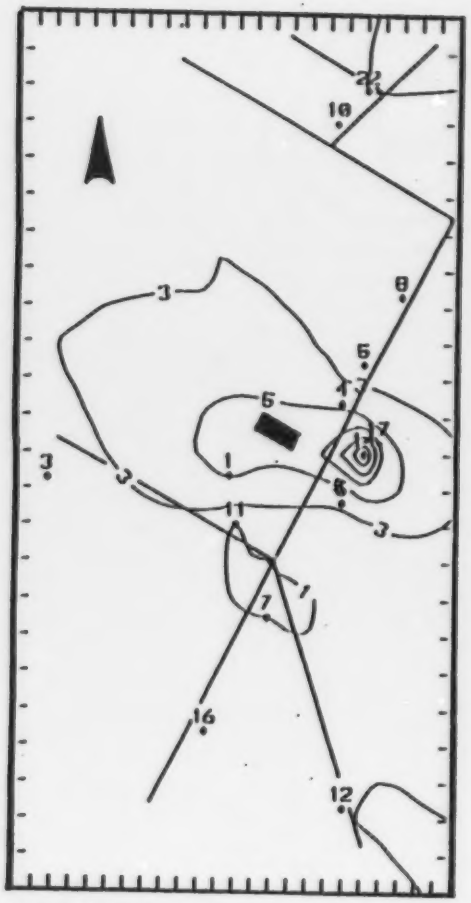


Contour Intervals - 10 ppm

Concentration values - ppm - dry weight

FIGURE: 6

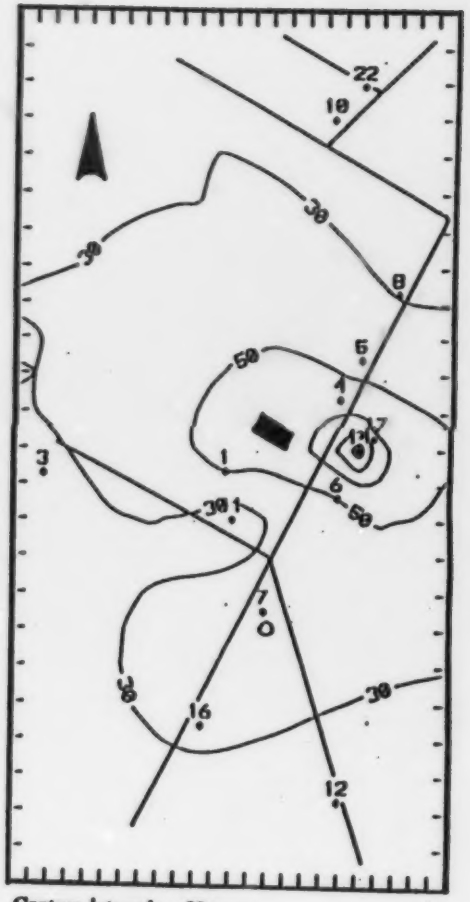
Contour Map of Nickel Concentrations
in Foliage Collected at Survey Sites Near
Crane Canada Inc., Stratford 1990



Contour Intervals - 2 ppm

FIGURE: 7

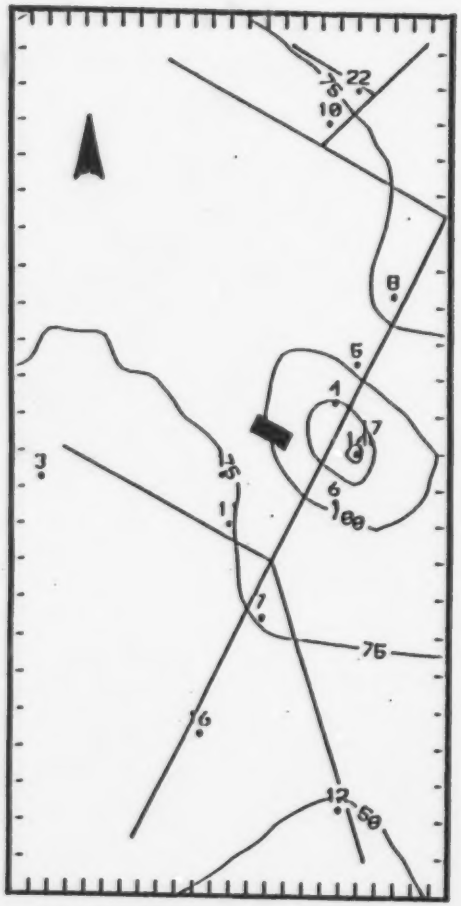
Contour Map of Sodium Concentrations
in Foliage Collected at Survey Sites Near
Crane Canada Inc., Stratford 1990



Contour Intervals - 20 ppm

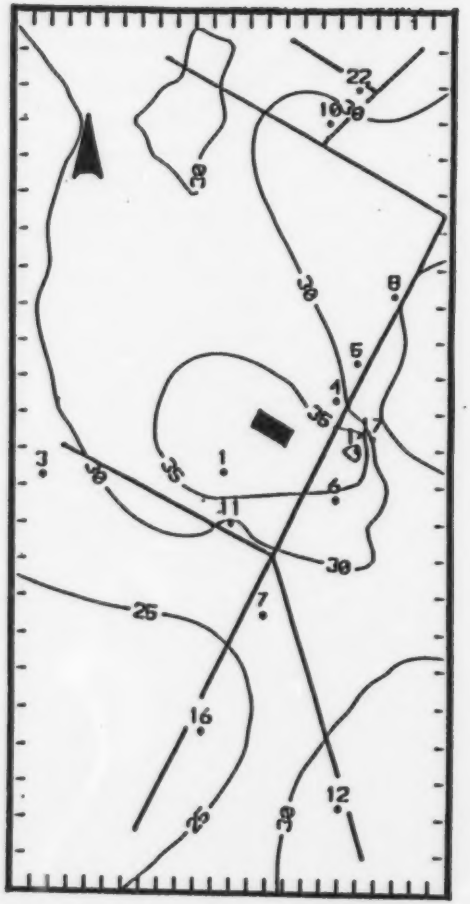
Concentration values - ppm - dry weight

FIGURE: 8 Contour Map of Aluminum Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour intervals - 25 ppm

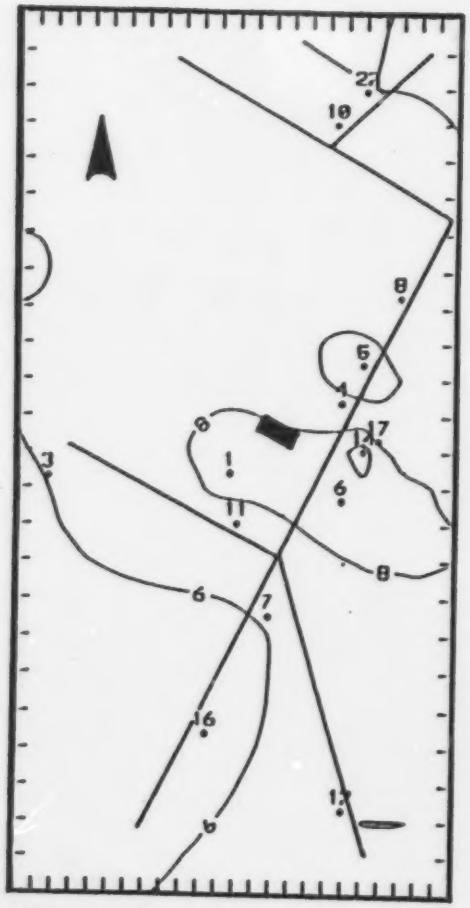
FIGURE: 9 Contour Map of Zinc Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour intervals - 5 ppm

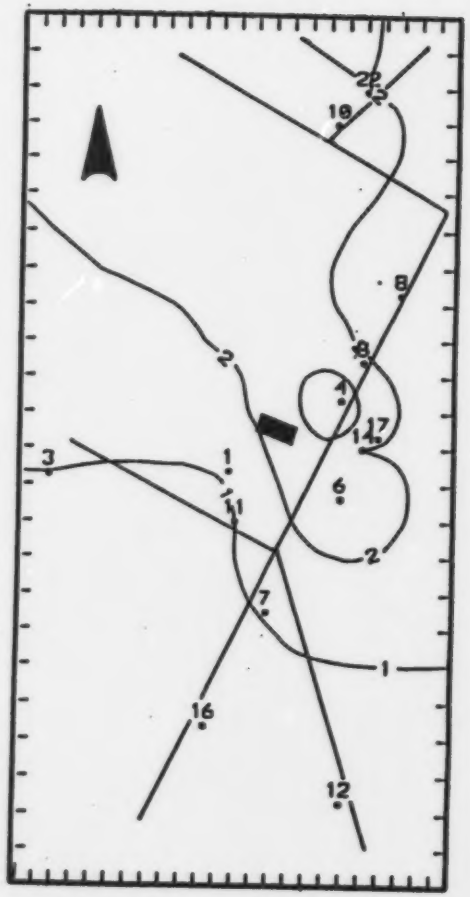
Concentration values - ppm - dry weight

FIGURE: 10 Contour Map of Copper Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour Intervals - 2 ppm

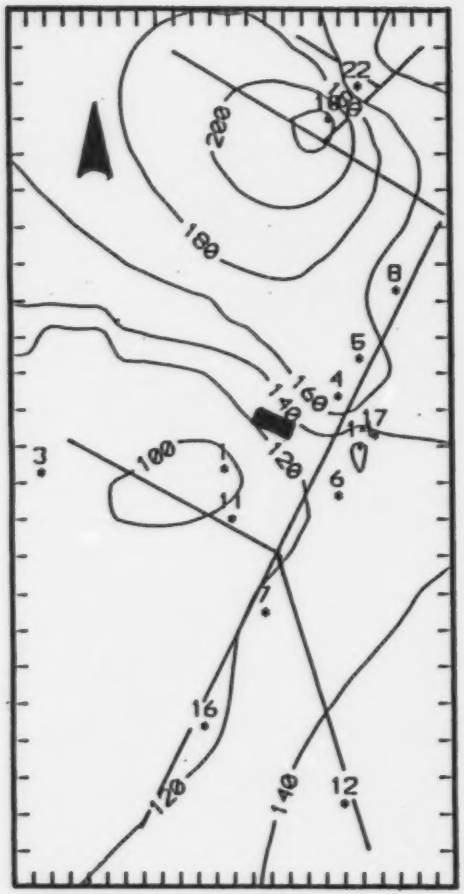
FIGURE: 11 Contour Map of Lead Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour Intervals - 1 ppm

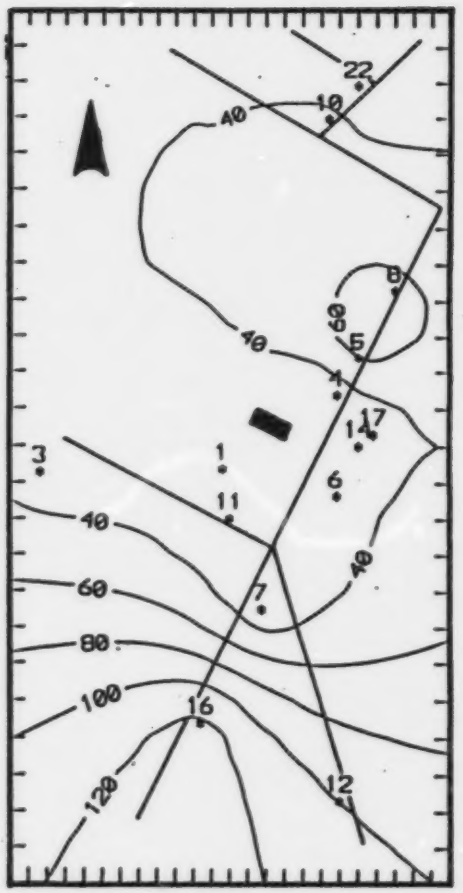
Concentration values - ppm - dry weight

FIGURE: 12 Contour Map of Iron Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour intervals - 20 ppm

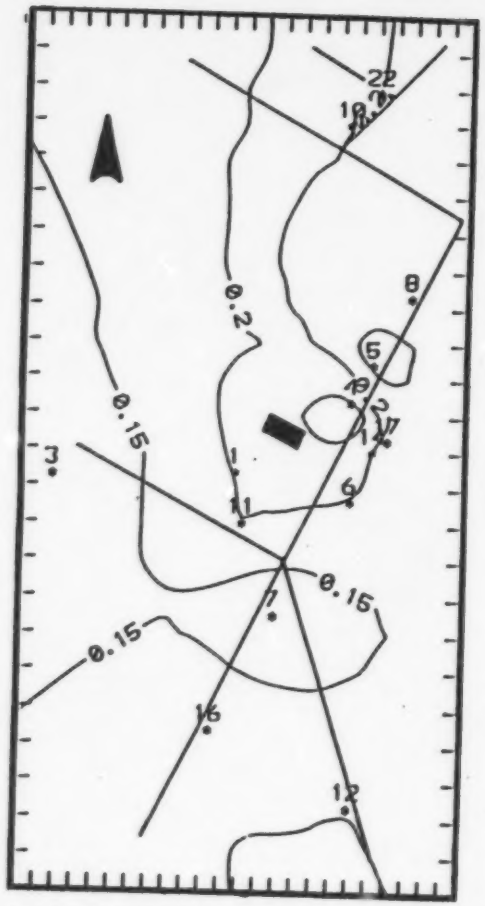
FIGURE: 13 Contour Map of Manganese Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour intervals - 20 ppm

Concentration values - ppm - dry weight

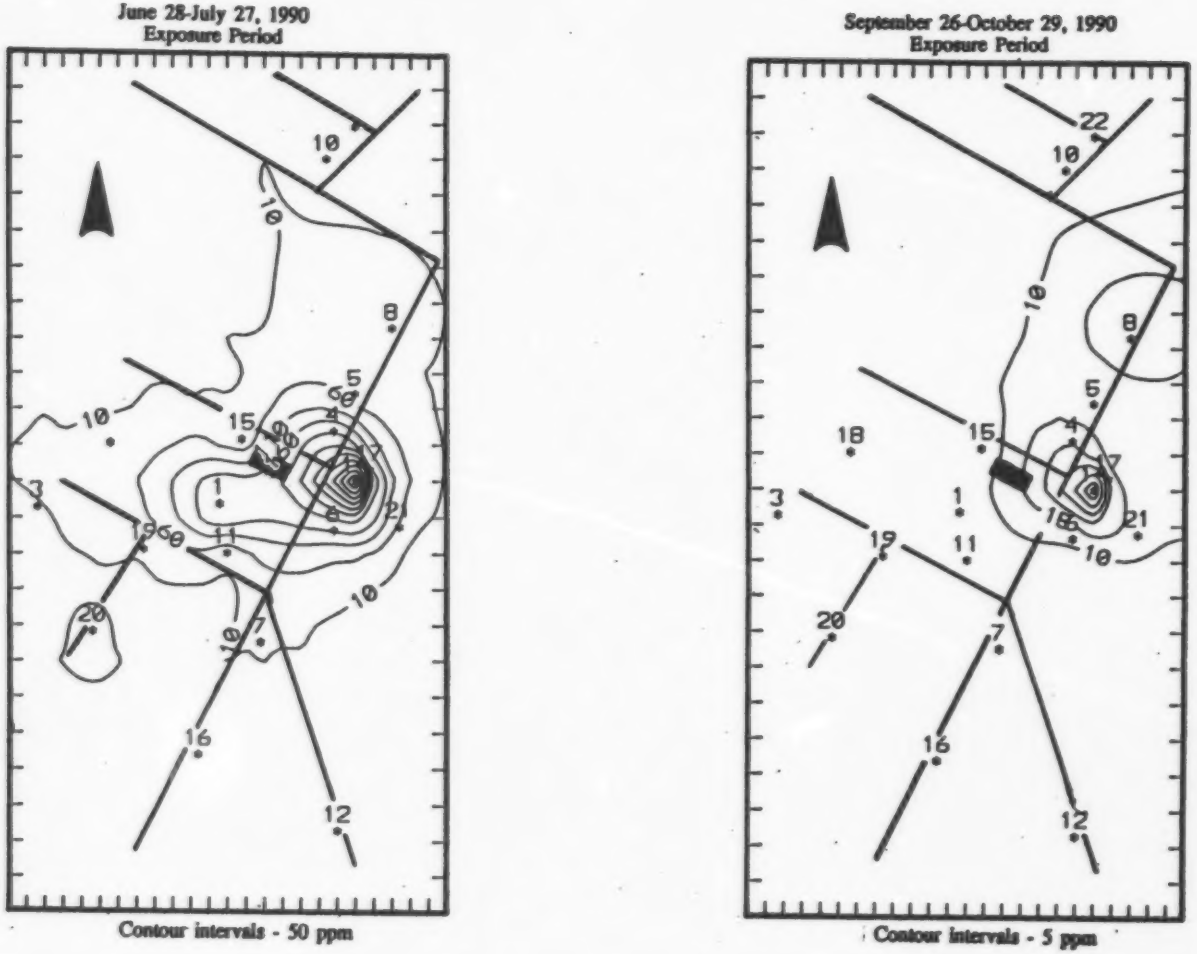
FIGURE: 14 Contour Map of Sulphur Concentrations in Foliage Collected at Survey Sites Near Crane Canada Inc., Stratford 1990



Contour intervals - 0.05%

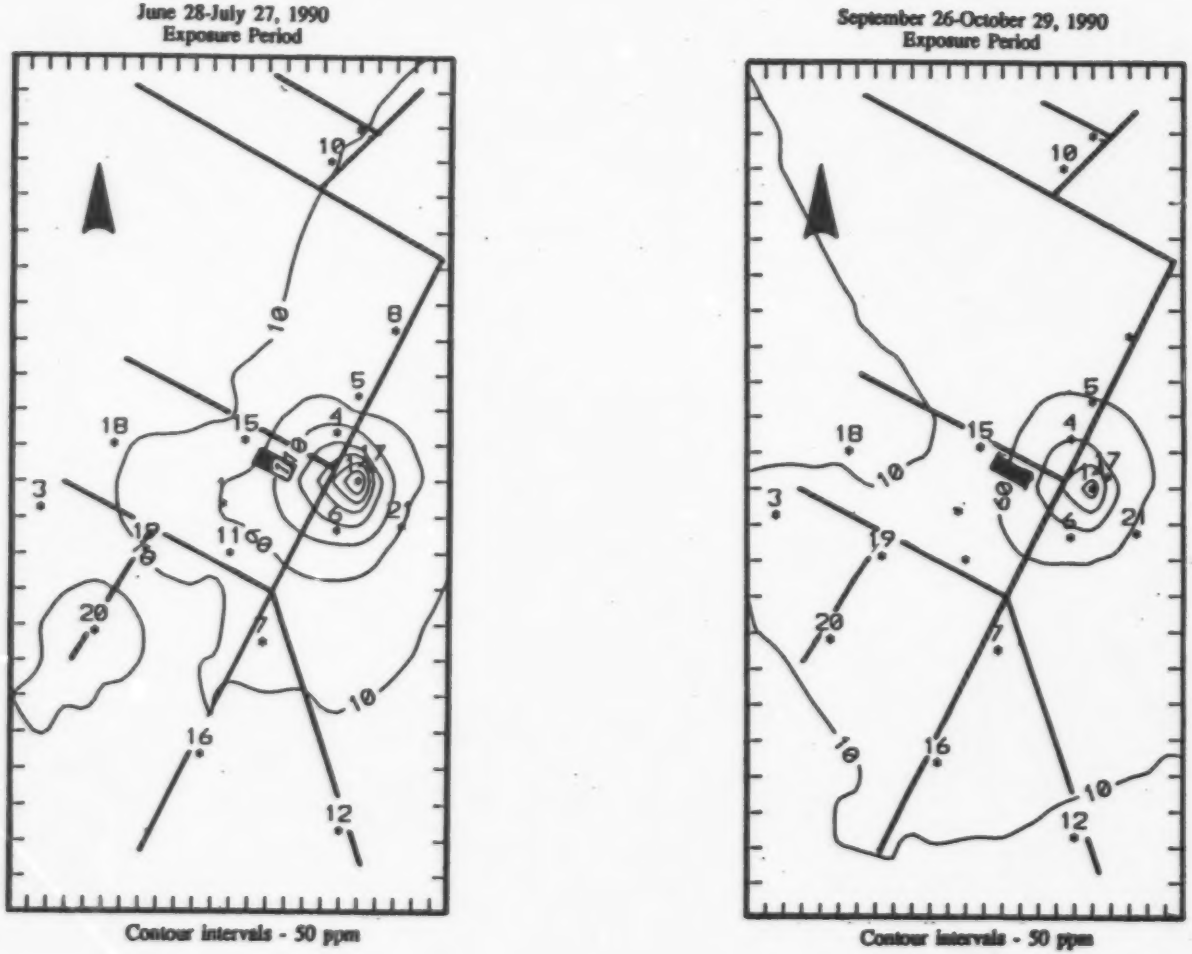
Concentration values - percent (%) - dry weight

FIGURE: 15 Contour Maps of Boron Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



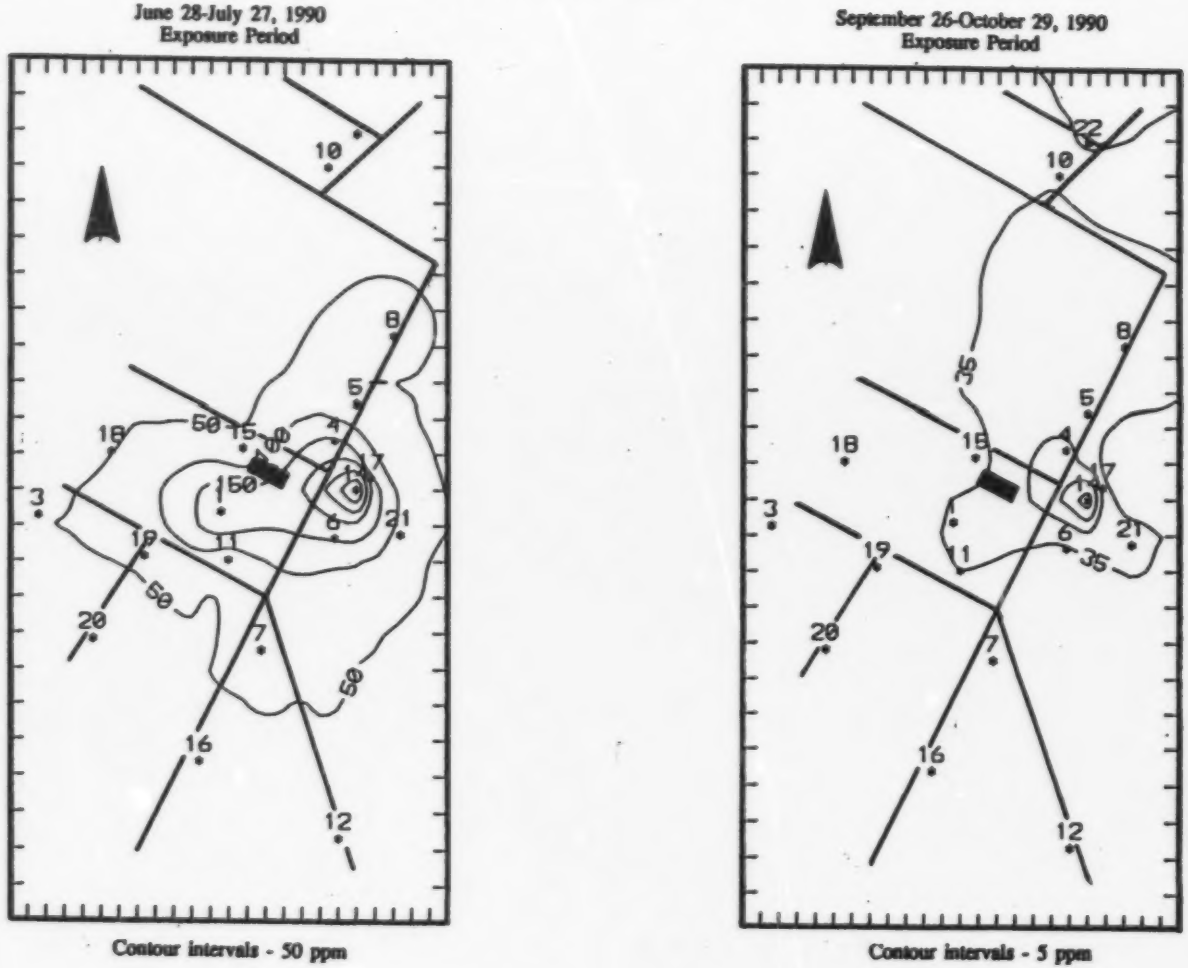
Concentration values - ppm - dry weight

FIGURE: 16 Contour Maps of Fluoride Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



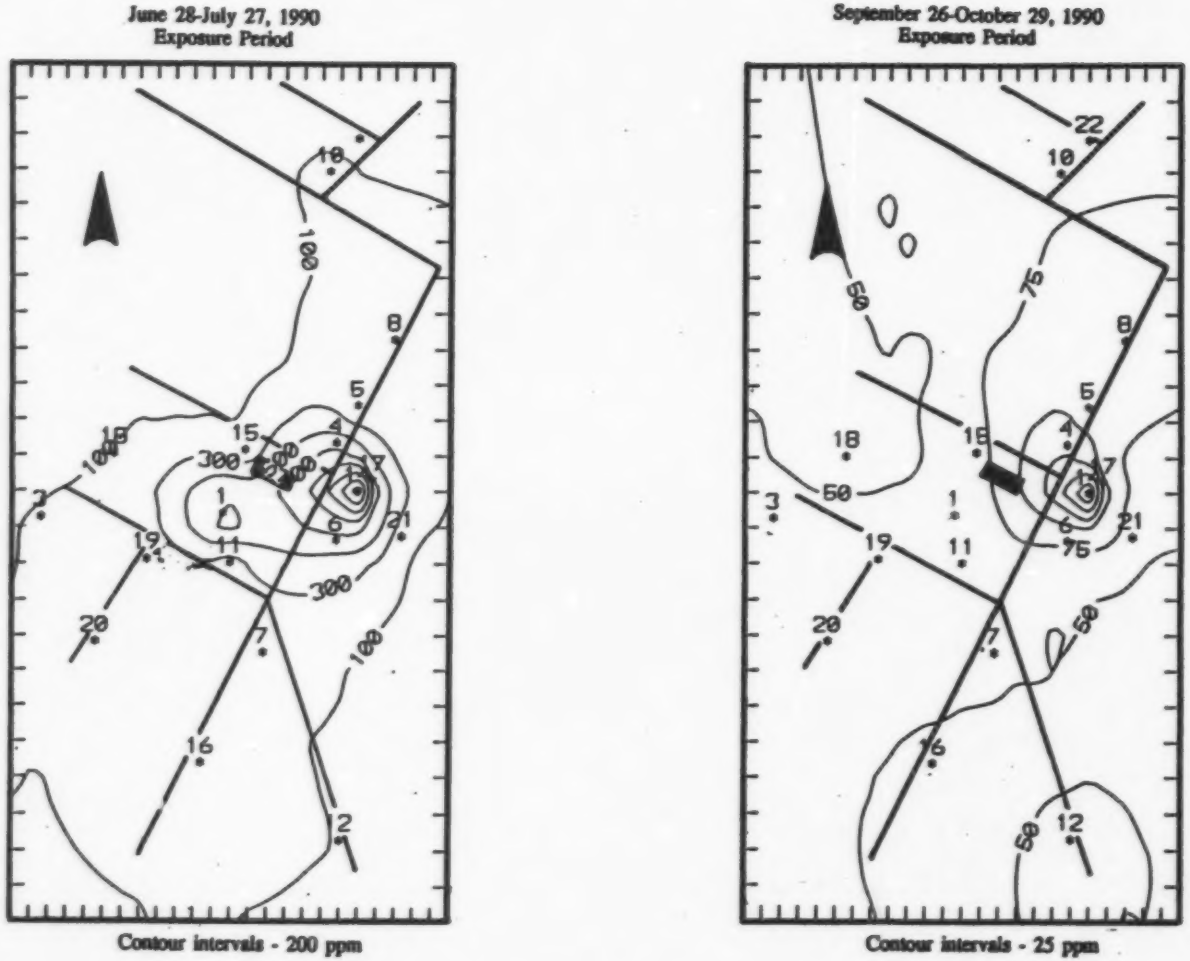
Concentration values - ppm - dry weight

FIGURE: 17 Contour Maps of Barium Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



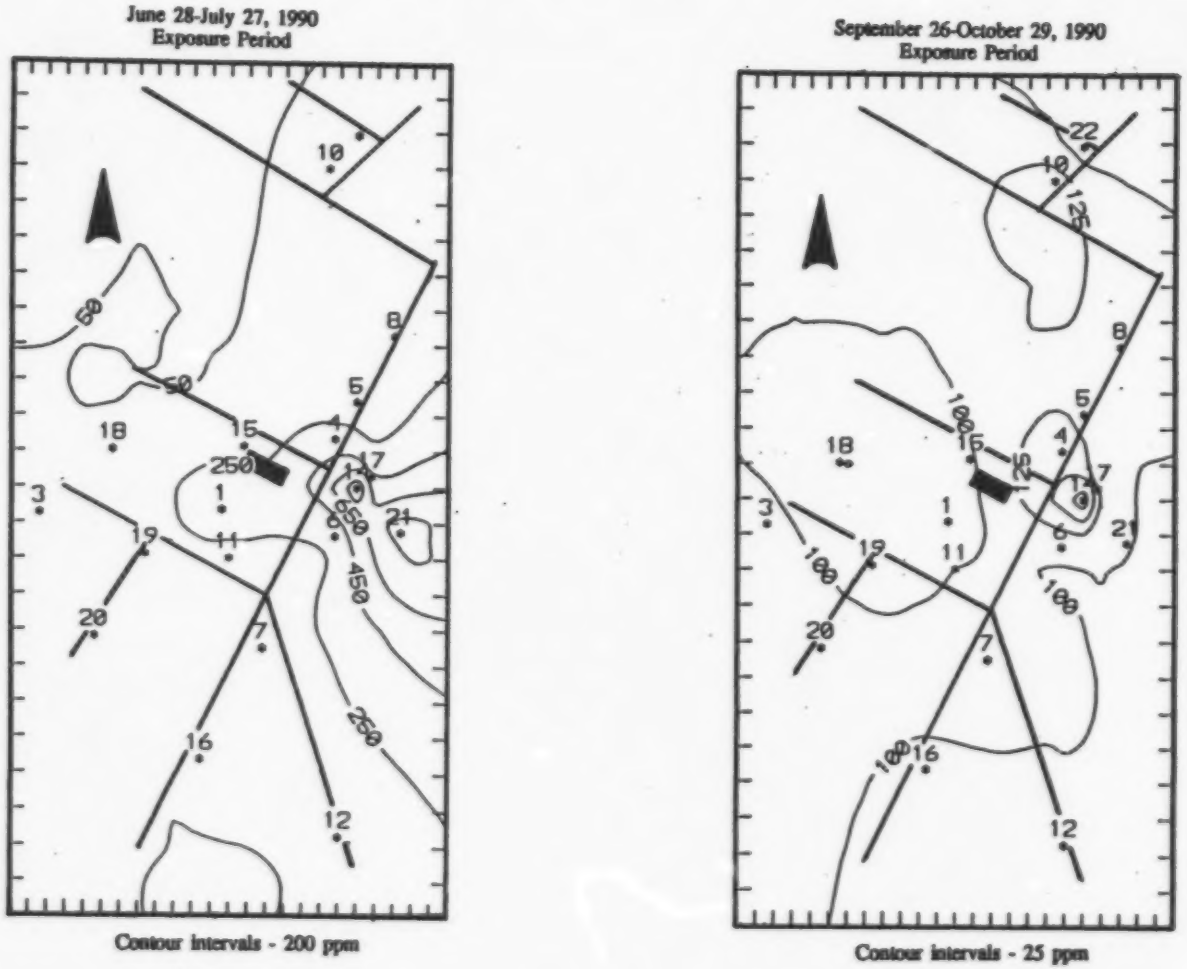
Concentration values - ppm - dry weight

FIGURE: 18 Contour Maps of Sodium Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



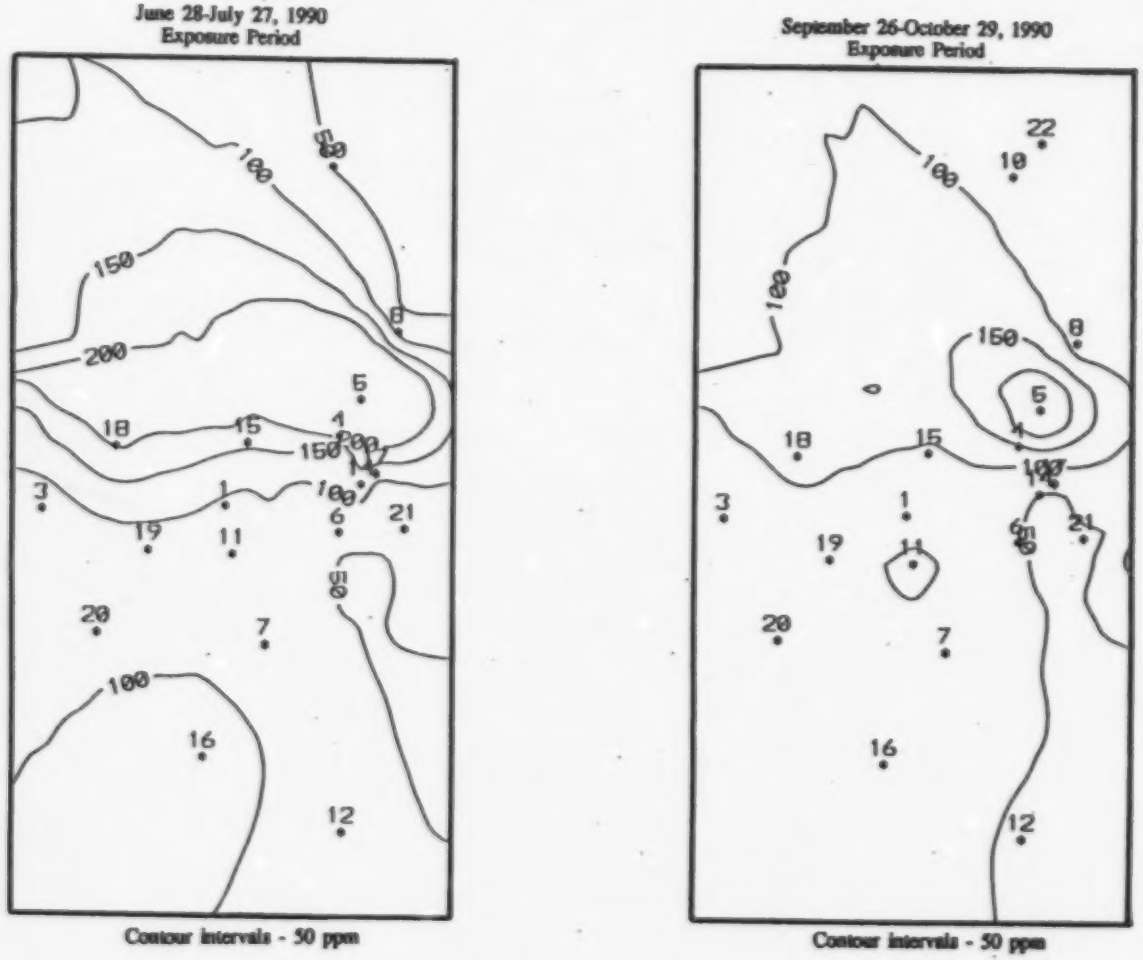
Concentration values - ppm - dry weight

FIGURE: 19 Contour Maps of Titanium Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



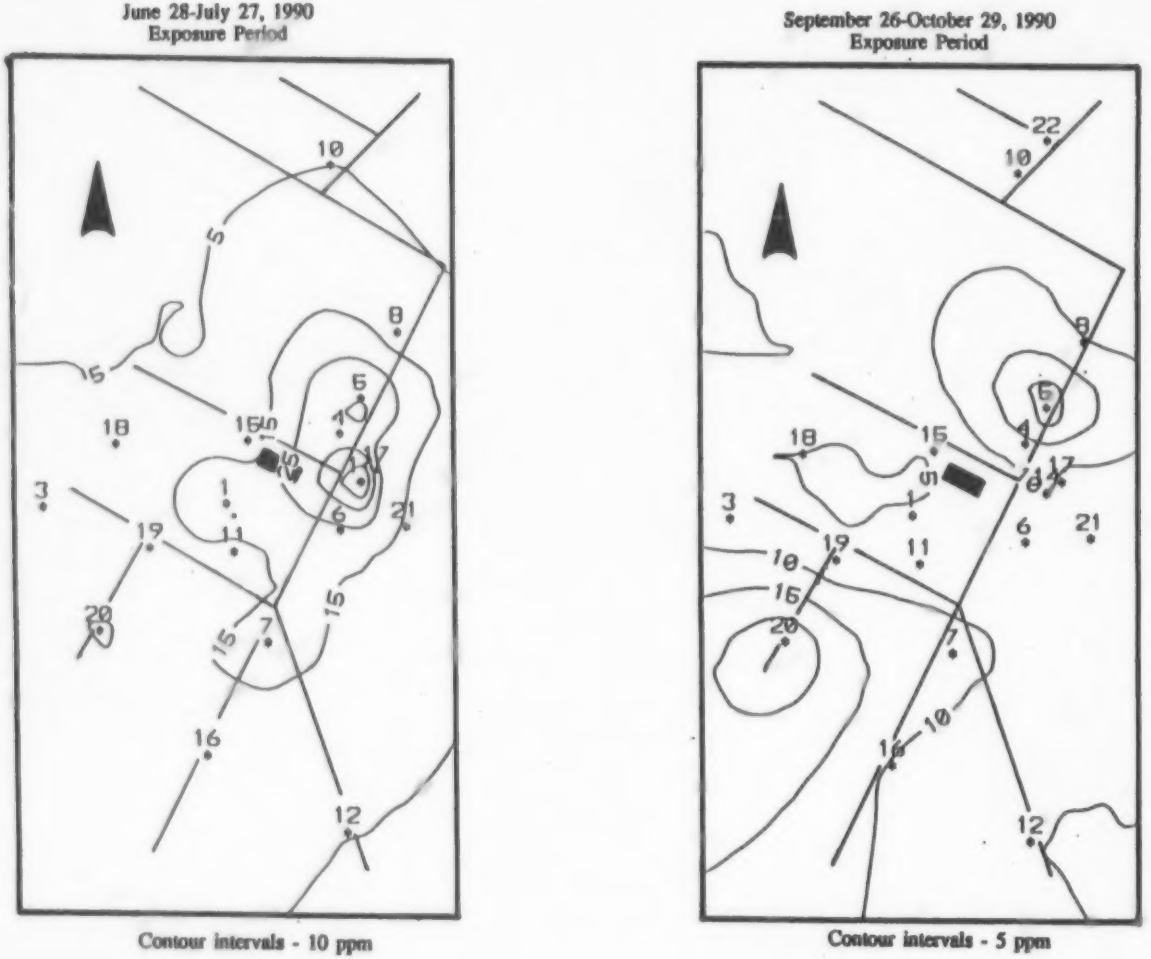
Concentration values - ppm - dry weight

FIGURE: 20 Contour Maps of Zinc Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



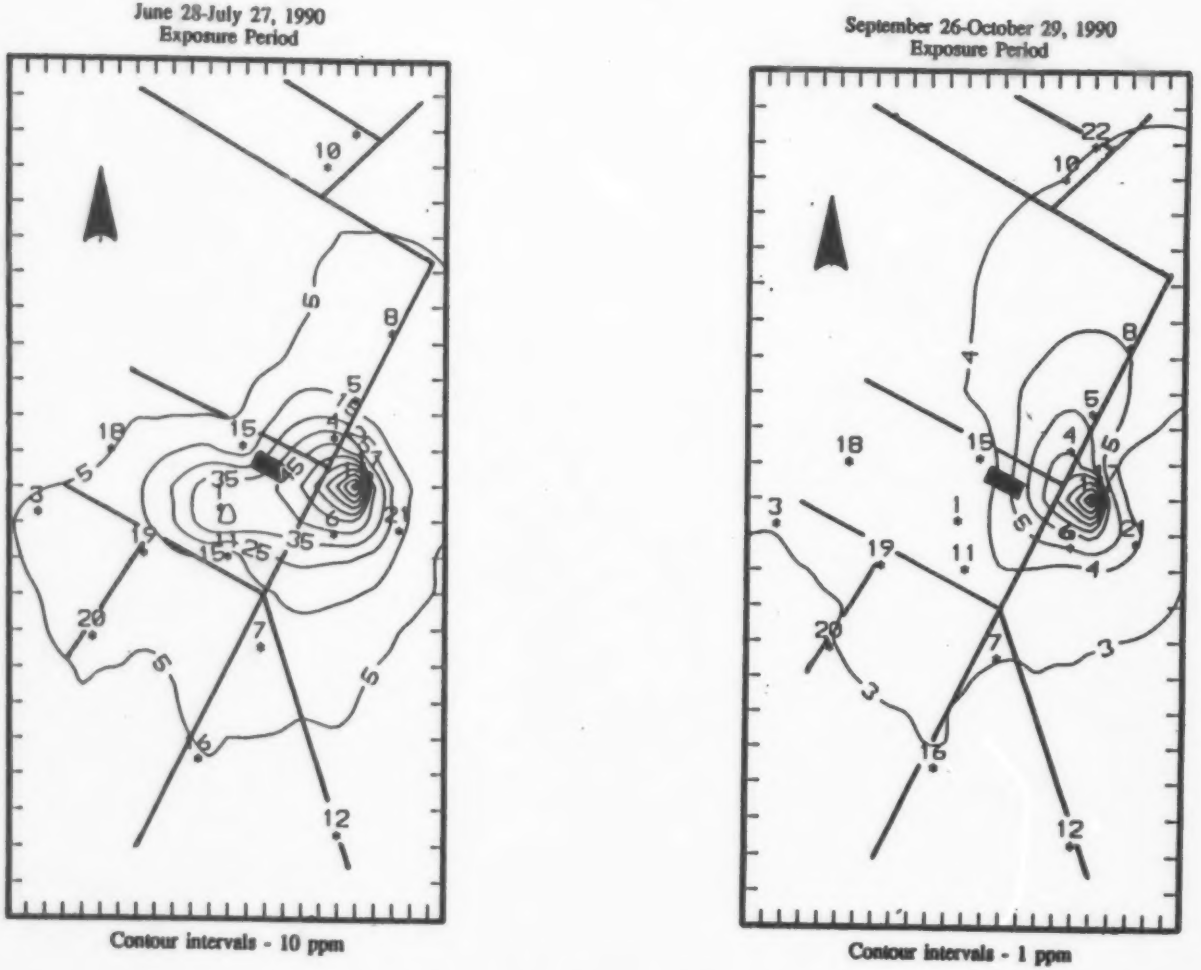
Concentration values - ppm - dry weight

FIGURE: 21 Contour Maps of Copper Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



Concentration values - ppm - dry weight

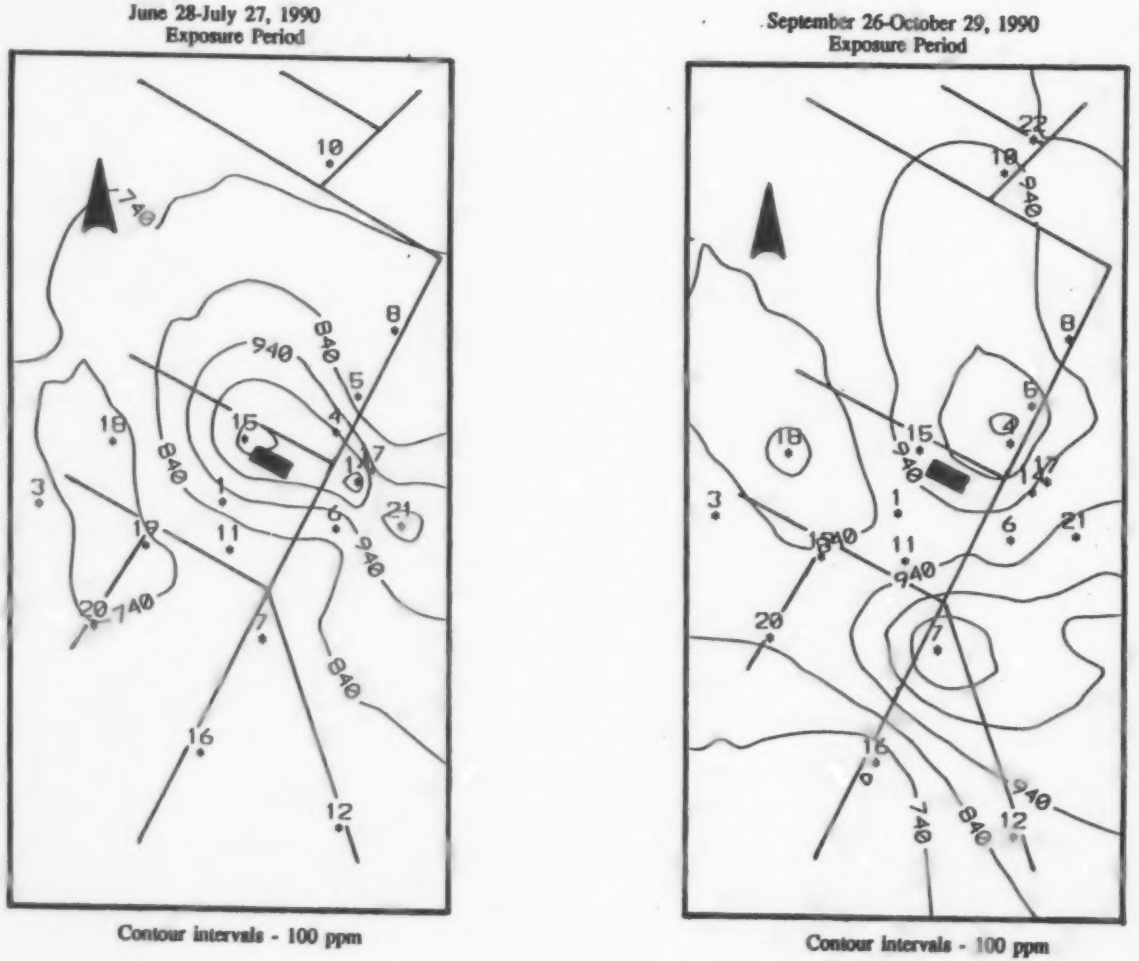
FIGURE: 22 Contour Maps of Nickel Concentrations Detected in Moss Bags in the Vicinity Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



Concentration values - ppm - dry weight

FIGURE: 23

Contour Maps of Aluminum Concentrations Detected in Moss Bags in the Vicinity of Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



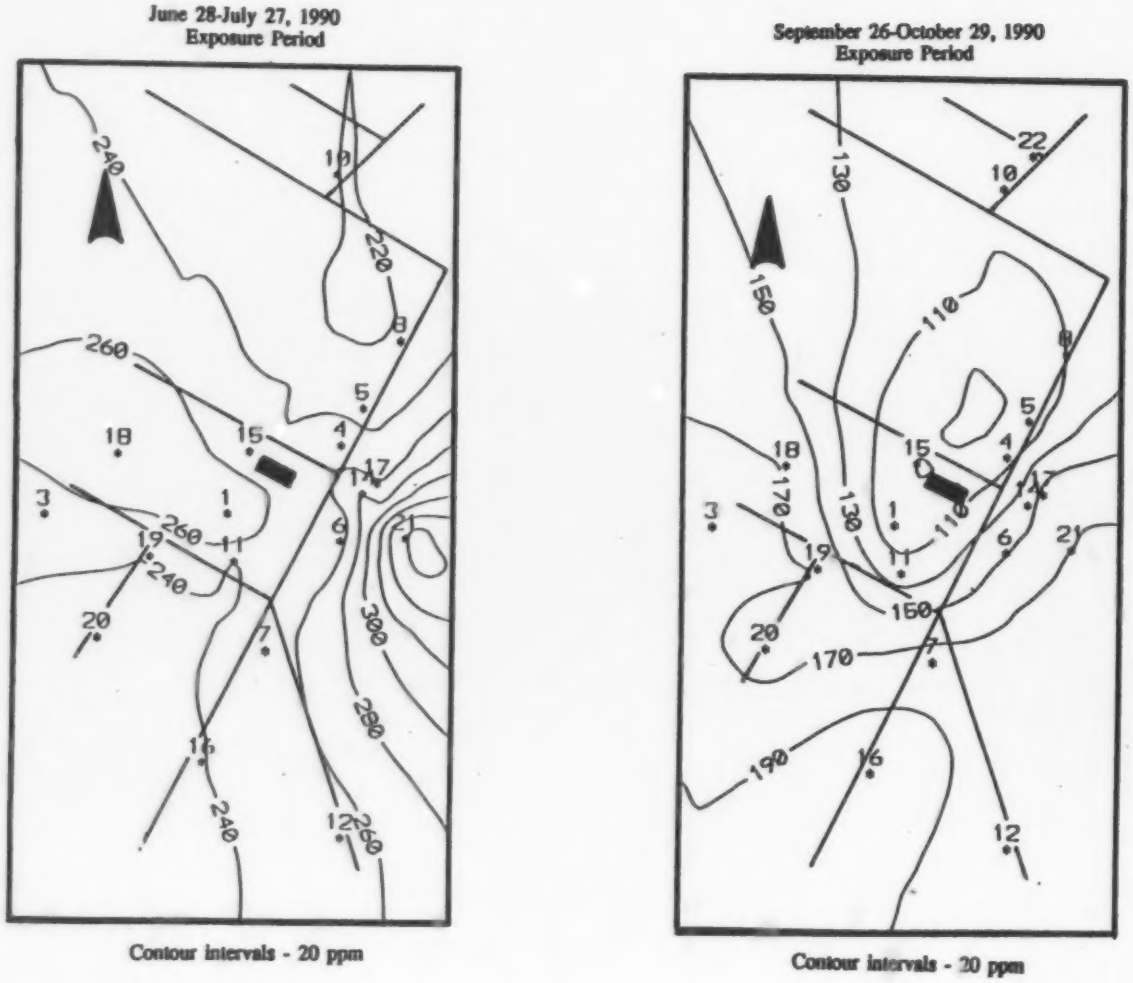
Contour intervals - 100 ppm

Contour intervals - 100 ppm

Concentration values - ppm - dry weight

FIGURE: 24

Contour Maps of Manganese Concentrations Detected in Moss Bags in the Vicinity of Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.



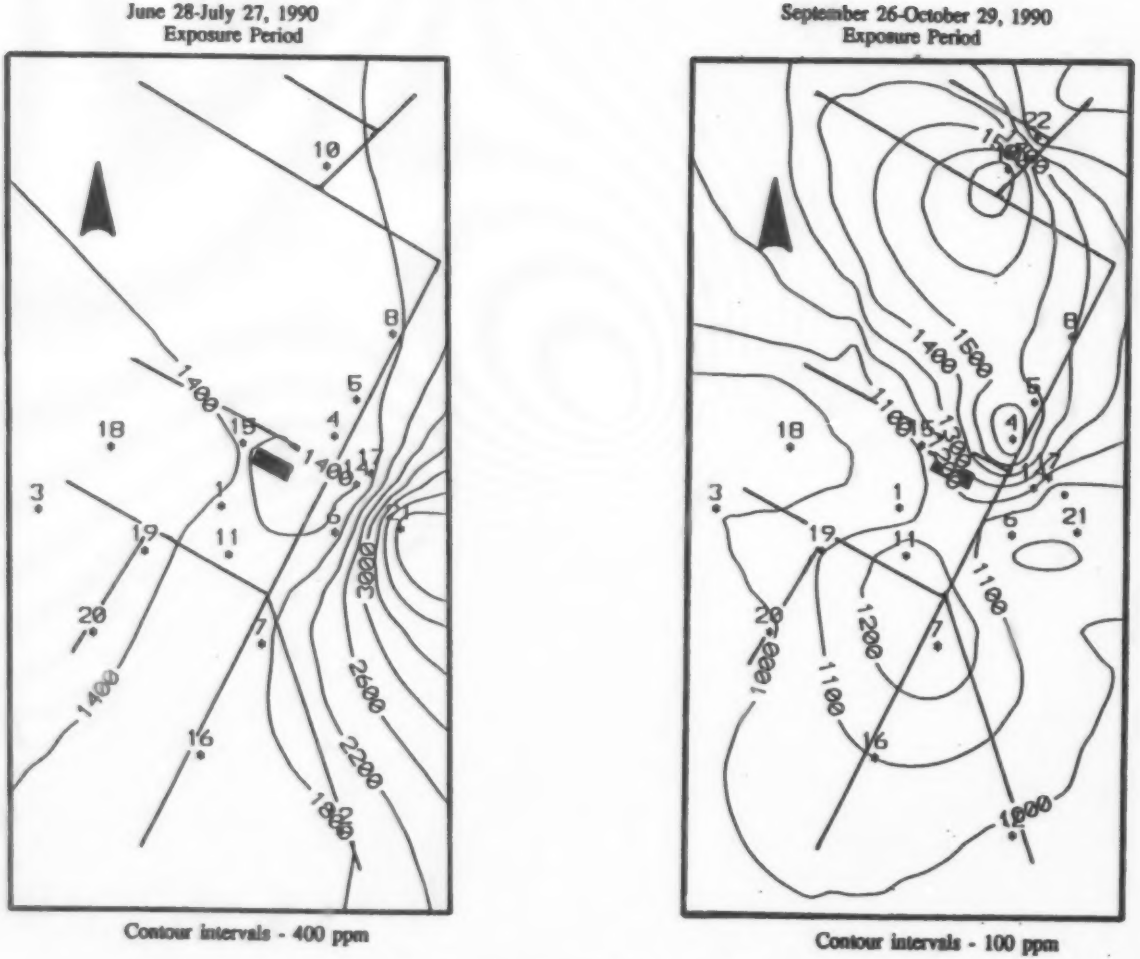
Contour intervals - 20 ppm

Contour intervals - 20 ppm

Concentration values - ppm - dry weight

FIGURE: 25

Contour Maps of Magnesium Concentrations Detected in Moss Bags in the Vicinity of Crane Canada Inc. During the First (June 28-July 27) and Final Exposure Periods (September 26-October 29), 1990.


June 28-July 27, 1990
Exposure Period
September 26-October 29, 1990
Exposure Period
Contour intervals - 400 ppm
Contour intervals - 100 ppm
Concentration values - ppm - dry weight